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Forthcoming Events.

JUNE 21—24.

British Foundrymen's Association.—Annual Convention in London.

JUNE 30.

Junior Institution of Engineers.—Gustave Canet Lecture. "The Working Fluid of Internal Combustion Engines," by Dr. Dugald Clerk, F.R.S.

NOTES AND COMMENTS.

The Steel Question in Cupola Working.

Despite the opposition which has been raised in many quarters against the use of steel in the foundry cupola for obtaining a closer and tougher iron, this material is constantly finding wider application, and increasingly large quantities of steel scrap, boiler, plate punchings, shearings and other similar refined material, find their way into the iron fouudry's cupola mixture. Probably much of the prejudice against this practice has resulted from lack of intimate acquaintance with the requirements of such mixtures as regards cupola operation. Even quite recently the opinion has been expressed by responsible foundrymen that the presence of steel may be responsible for hard shots and segregated hard parts in iron castings, but this suggestion is not accepted as being feasible. So far from the suggested difficulty of melting steel in the cupola, although its initial carbon is very low, say, 0.5 per cent., it is quite customary to find the steel coming down before the higher grades of iron, *i.e.*, Nos. 1 and 2. Quite recently, a well-known foundryman, in discussing the question of the distribution of the different charges, gave his experience to the effect that it was advisable to charge steel mixtures in the early part of the blow, as they were liable to melt and run down into a softer iron if they were charged later. The cause is briefly this, that while steel commences with a low initial carbon, owing to its purity and the absence of metalloids, it readily absorbs carbon in the furnace, and thus lower its melting point, while other classes of iron saturated with a highly refractory carbon do not so readily absorb carbon from the furnace gases or coke, and hence do not melt so readily. It is quite conceivable under these conditions that unless the furnaceman is familiar with the phenomenon of steel melting in the cupola, he may get very irregular results, particularly when still employing the blast pressure and volume formerly used with the pig- and scrap-iron mixture. There has in the past been a great tendency to use undue pressure of blast and limit the volume of air in cupola working, and while the results of this are not always conspicuously bad with pig and scrap mixtures, they may have a very different effect when the charge is of a different nature. This has been well appreciated by the well-known American authority on the use of steel in cupola mixture, Mr. David McLain, who found it essential to specialise in the work and thoroughly systematise the cupola operations in oredr to get the best results from steel additions, and in this he has unquestionably succeeded. It is, of course, open to any foundryman to do the same, given sufficient opportunity to make the necessary experiment and trials, but many find it difficult to break away from old prejudices and their established ideas of cupola working. Without doubt, there is room for radical improvement and a complete reconsideration of the methods adopted by many foundrymen in operating cupolas, and particularly does this apply to the question of blast pressure and volume. We do not propose at the moment, however, to anticipate an im-

portant paper on this subject which will be presented this month by Mr. F. J. Cook before the British Foundrymen's Association. Suffice to say, the great variance between the practice of one foundryman and that of another is a clear indication that in some quarters the correct lines are not being nearly approached. We have, at various times, drawn attention to our readers to the value of steel additions in the cupola, and while not advocating the promiscuous use of this material, we would point out that there is unquestionably a large field of possibilities before it, particularly in the hands of anyone conversing with the requirements of its use. It has been successfully employed by many intelligent foundrymen who have taken the trouble to go into the subject, and its possibilities should be studied by all who would keep pace with modern engineering requirements.

False Assumptions on Economics.

At the present time, when the economics of industry are so much under discussion by different societies and individuals, it is interesting to observe how readily authoritative writers will fall into elementary errors and base profound conclusions upon false premises. This was illustrated in one of a series of articles recently contributed to a weekly contemporary by a well-known writer, Mr. L. G. Chiozza Money, who discusses "The Economy of High Wages." We are not disposed to entirely disagree with the assumption that high wages are generally associated with high efficiency, but we must object to the said writer's method of arriving at this conclusion. His first observation is that a better wage produces a better man, and that this dictum is based upon experience. He proceeds to illustrate this by reference to the cotton trade, where improving conditions of labour have compelled efficiency in the trade, and, therefore, a great productivity. It is quite true that "It is ever the low-wage trade that is inefficient," for the simple reason that efficiency is largely effected by the conditions of living of the workers, and those conditions cannot be maintained at a high standard upon a low wage; but at the same time, it is fallacious to conclude that a high wage *per se* produces high efficiency. It would not be difficult to refute this suggestion by recalling quite a number of highly-paid classes of labour of extremely low efficiency, this effect being produced by various extraneous circumstances. The more correct assumption is that wage corresponding to efficiency tends to stimulate efficiency, and that likewise wage appreciably lower than efficiency tends to deteriorate efficiency; this as a general assumption is correct. But to contend that a high rate of pay, as such, governs efficiency is to engender a false impression in the minds of many, and obscure the fact that wage is (or should be) representative of the worker's value to the community. That value is the basis factor, and it tends to increase as the wage becomes more nearly representative. There are, however, various factors effecting the rate of pay for any work, and these factors include many matters of pure sentiment. Taking for example several mechanical trades, each requiring about the same mental capacity of physical ability, almost invariably the wage will be found to increase as the character of the operations becomes dirtier or less pleasing to the eye, even though not actually unpleasant in practice. Circumstances, also, have associated rather more dignity with some trades than with others, and hence some are more sought after, and correspondingly less well paid than others requiring equal capacity, but with less desirable sentimental associations.

Mr. Money proceeds:—"When a master in any trade is compelled to pay higher wages—no matter whether the compulsion be that his men have alternative employments offered them, or that they combine together in a trade union and demand a better wage, or that the law steps in, as under the Trades Boards Act, and says that he shall not pay low wages—the master has to look about him and mend his ways. Experience shows that he does not content himself with paying the higher wage forced upon him. He looks round to see what economies he can make to compensate him for the higher wage, and in the general case he soon finds means of effecting economies." This is quite true, for very often the fact of being able to pay low wages obscures the possibility of great economy in other directions. But again it should be apparent that it is not the high wages as such that increase the efficiency; it is the improved organisation and increased demand for competence in the worker, which is the main factor in increasing efficiency. This same organisation could be accomplished and the demand for greater competence could be made, without increasing the wage; but, of course, the attempt would be largely nullified by reason of the wage not being sufficient to maintain the competency of the worker. The essential point to be observed is that while a low wage undoubtedly tends to decrease efficiency, a high wage does not of itself increase efficiency; it only permits increased efficiency. The distinction may seem purely academic, but it is of more than academic importance, for the reason that the false assumption as the base of a claim for adequate wages allows the claim to be refuted by reference to the simple fact that high wages can obviously be paid without increasing efficiency.

Starting, then, with the assumption that "wages commensurate with efficiency, tend to increase efficiency," it is possible to construct quite a sound argument for increased payment in many branches of industry. It has, in fact, been a matter of surprise to many employers to find to what extent they can increase the wages of some classes of labour, while at the same time increasing the return from that labour. But this is only possible by higher organisation and increased efficiency, rendered possible by (*but not directly created by*) higher wages. It is very necessary in discussing the delicate subject of labour and wages to draw these distinctions, for neglect to establish clear ideas on the matter too frequently leads to more misunderstanding and wrong conception than all the good the teaching can possibly do.

Effect of Titanium on Cast Iron.

Experiments have shown that iron may be increased in strength as much as 43 per cent. by the correct use of titanium; but, to accomplish the best results, the titanium must not only be in correct proportions, but the iron must be given a fair chance by allowing the titanium a full opportunity to become thoroughly dissolved in it (not less than three minutes' treatment), so that it is neither wasted in the slag nor left unmelted in the ladle, and by insuring that the iron is poured neither too hot nor too cold. The following results have been obtained by different investigators:—

	Used. Ferro-titanium.	Increased. Tensile strength. Per cent.	Increased. Transverse strength. Per cent.
Rossi	Alloy	30 to 50	20 to 25
Schiemann	Thermit	30 to 50	
Rossi	Alloy	6 to 30	17 to 23
Goldschmidt	Thermit	4 to 16	1 to 17
Moldenke	Alloy		18 (white)
Moldenke	Alloy		52 (grey)
Guillier			49 (mall iron
Guillier			14 to 30(grey
Feise	Alloy		35
Treuheit	Thermit & alloy	No important change.	
Gale	Alloy		10 to 20
Alexander	Alloy	Increased ductility.	
Geiger	Alloy	12 to 26	6 to 10
West	Alloy		27 to 32
Stoughton	Alloy		10 to 43

The Iron and Steel Institute.

Annual Meeting in London.

The 44th annual general meeting of the Iron and Steel Institute opened in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, on Thursday, May 1, under the Presidency of Mr. Arthur Cooper.

There was a very good attendance at the meetings for the presentation and discussion of Papers, and some interesting and lively interchange of opinions took place.

The Bessemer Gold Medal for 1913, which the Council had awarded to Mr. Adolphe Greiner, D.Sc., in recognition of his distinguished service to the iron and steel industries, was presented during the first day's meeting.

THE PAPERS.

Among the Papers before the meeting was one by Mr. Benjamin Talbot, "On the Production of Sound Steel by Lateral Compression of the Ingot whilst its Centre is Liquid." This was of an extremely interesting nature to steel-makers, and was followed by a lengthy discussion.

Among others, a valuable Paper on "Studies in the Cold Flow of Steel" was presented by Mr. Percy Longmuir, M.Met., while Mr. W. H. Hatfield dealt with "The Influence of Sulphur on the Stability of Iron Carbide in the Presence of Silicon."

Soft Steel at High Temperatures.

So far as the chemical Papers were concerned, however, the chief interest centred round those on "The Tenacity, Deformation, and Fracture of Soft Steel at High Temperatures," by Dr. W. Rosenhain, and Mr. J. C. W. Humfrey, and "The Critical Ranges of Pure Iron: with Special Reference to the A_2 Inversion," by Professor H. C. H. Carpenter, of Manchester University. In the first of these two researches, the general objects were, briefly:—(1)To obtain a curve indicating the relation between temperature and tensile strength ("tenacity"), particularly over the range of temperature covering the critical points of iron or very-low-carbon steels. (2) To make a systematic microscopic study of the modes of deformation and fracture of iron or very-low-carbon steel over the same range of temperature.

The results obtained by the author's experiments may conveniently be discussed in two groups, namely, those relating to the mechanical data derived from the stress-strain diagrams and those relating to the micro-structure of the strained specimens.

The numerical results of the authors' experiments entailed over two hundred tensile tests, and are given in six tables. The mechanical results have been obtained in the form of stress-strain diagrams, which show the striking nature of the change, both as regards tensile strength and ductility, undergone by iron or very soft steel on passing through the temperature range from 650 deg. to 1,100 deg. C.

"Leaving aside the small break in the curve corresponding to the point Ar_1 (the carbon transformation), the temperature-tenacity curve consists broadly of three branches corresponding to the γ, β, and α ranges of iron. Throughout the γ range, that is to say, from 1,100 deg. to 900 deg. C., the curve shows a uniform upward sweep. About 900 deg. C. the curve drops suddenly, and for a short distance below the critical temperature the results of tensile tests have been found to vary somewhat irregularly—a circumstance which is readily explained by the fact that the exact condition of the material so near the critical range or even within it is somewhat uncertain, depending upon the precise extent to which the transformation from the γ to the β condition has taken place. For a short distance below 900 deg. C., therefore, the curve is shown as a dotted line, and cannot be regarded as definitely established. The temperature-tenacity curve shows a very well-defined minimum approximately in the centre of the β region, that is, about 830 deg. C."

"The general results indicated by the curve may be briefly stated as follows:—(1) There are two very well-marked discontinuities in the temperature-tenacity curve corresponding to the critical points Ac_3, Ar_3, and Ac_2, Ar_2 respectively. (2) The larger of these discontinuities, *i.e.*, the one implying the largest change in tensile strength, occurs at the transition from the γ to the β condition. The smaller one corresponding to Ar_2, is, however, perfectly definite, and its existence must be taken into account in any discussion concerning the existence of β iron."

"In comparing these conclusions with the deductions drawn by the present authors from their earlier experiments, described in a Paper presented before the Royal Society in 1909, it will be seen that although in general terms the quantitative measurements confirm the results of the earlier qualitative work, they yet required some modification of the earlier conclusions. In view of the fact that the discontinuity in mechanical properties which occurs at or near 900 deg. C. is now seen to be so very much larger than that which occurs at or near 750 deg. C., it seems probable that the microscopic discontinuity observed by the authors in 1909, and ascribed by them to the transition from the α to the β condition, is in reality due to the transition from the β to the γ condition; and further, the fracture of their specimens at a point whose temperature was well below that of the hottest part is explained by the occurrence of the minimum in the temperature-tenacity curve near 830 deg. C. As the temperature measurements in the earlier work were admittedly of an approximate character, there seems no difficulty in reconciling the observations then made with the facts now established. The theoretical conclusions, on the other hand, may require more modification."

"Taking together the results of the microscopic examination and the mechanical tests, certain interesting conclusions may be drawn in a rather more definite manner. Commencing with the material at the higher temperature of these experiments, that is, well above Ar_3, we find that it possesses the mechanical properties and the microscopic behaviour of an aggregate of crystals, themselves relatively strong, embedded in a viscous fluid. Throughout the γ range these characteristics are maintained, although the actual fluidity of the intercrystalline cement no doubt diminishes steadily with decreasing temperature. The allotropic modification which occurs at Ar_3 affects the crystals alone without altering the character and properties of the cement; as a consequence of the allotropic change the crystals

become very considerably weaker, so that the relative importance of crystals and cement from the point of view of strength is reversed after passing Ar_3; the crystals now being relatively weak, yield first, while the cement is relatively hard and stiff. The change makes itself felt in two ways: in the first place the tenacity-temperature curve drops suddenly and follows a totally different law from that which governed its course in the γ region, and in the second place the strength of the material is now very largely dependent upon the crystal size, since the proportion of the harder and stronger cementing material is much higher in a fine-grained structure than in a coarse-grained one, and the presence of this harder material makes itself felt more directly, and also indirectly by acting as a stiffening which resists the tendency of crystals to undergo plastic deformation."

"The allotropic change at Ar_2, although clearly indicated by discontinuities in all tenacity-temperature curves, does not make itself felt very strongly in any of the other observations, and beyond the fact of establishing the existence of a mechanical discontinuity the present research throws little light on the nature of the change from β to α iron."

"The bearing of the results of the present research on the allotropic theory of the hardening of steel is perhaps of some interest. Inspection of the temperature-tenacity curves clearly shows that the allotropic change at Ac_3, Ar_3 brings with it the greatest change in mechanical properties. On the other hand, the question whether the β modification of iron plays the principal part in the hardening of steel is still an open one. The shape of the curve does not justify any very definite exterpolation towards the ordinary temperature, although it seems tolerably certain that if the γ or β curve could be produced down to the ordinary temperature it would correspond to material very much harder than α iron. Whether, however, these two curves would retain their relative positions, thus making the γ iron the harder at the ordinary temperature, or whether the two temperatures may cross, cannot be concluded from the present results. All that can be definitely said is that the present research clearly demonstrates the occurrence of at least one important transformation which takes place in iron at a temperature near 900 deg. C., and that this transformation results in the formation of a considerably harder and stronger body usually called γ iron. A similar but much smaller change is indicated definitely at the temperature of Ar_2, and the authors find it difficult to reconcile the occurrence of such a discontinuity with such a theory as that of Benedicks, by which β iron is regarded as a solution of γ iron and α iron. On the other hand, the present observations, apart from the mechanical discontinuity, do not indicate any very striking difference between β and α iron."

Dr. J. O. Arnold, in the discussion that followed, sincerely congratulated Dr. Rosenhain and Mr. Humfrey on their very valuable research. He noted that they had found it impossible to work with the electrolitic iron, and had experimented with a tinplate steel. With reference to their former Paper, he noted that the authors desired to modify the views then expressed. Dr. Rosenhain had failed to split Ar_2. There was no doubt that they were horrified to find that they got a lower stress and a higher elongation in the β range instead of what they expected. They tried to explain it away, but that would hardly do. The real explanation of the results attained had entirely escaped the attention of the authors. A correct analysis of the results showed that the old β theories were as dead as the Doges. When he looked back over twenty years and thought of the long course of pseudo-scientific coquetting round the β-iron theory he was almost inclined to use strong language. That theory had stopped the advance of the scientific chemistry of steel. It was now dead.

Dr. H. C. H. Carpenter agreed that it was an under-statement of the position now existing for the authors to refer to this Paper as merely a modification of the earlier Paper. It really destroyed the whole ground of the earlier Paper. He thought they were unwise in that earlier Paper to put forward the interpretation they did, as the result was to give a new life to the moribund β theory; because their conclusion was that the chief change in the properties took place on passing from α to β iron. They said nothing about γ iron in the first Paper, and the impression left was that there was a marked increase of hardness in passing from the α to the β stage. That was wrong, and they had shown it in this present Paper, where it was made clear that the great change was in passing from β to γ. With regard to Dr. Benedicks' hypothesis and its relation to the work described in the present Paper, it had to be remembered that the authors were not dealing with the pure iron. In his own opinion the results fitted in completely with Benedicks' theory, which would predict a large inversion in passing through the γ range, and the Paper really confirmed Benedicks' theory in the strongest possible way.

Sir Robert Hadfield said it was not a little satisfactory to one who had fought against the allotropic phase of thought to find that the authors' conclusions were much the same as those which his own experiments many years ago seemed to prove. He believed he was one of the first, if not the first, to put forward a modern theory that iron might assume another or allotropic form; but it was not long before further researches clearly showed that his first suggestions in this direction were not tenable, simply for the reason that he had overlooked the very great importance and influence of carbon, even in varying small percentages. Whilst he could not agree with the allotropists, and rejoiced to find that they were now coming to his way of thinking, yet he freely admitted that the very differences in the past stimulated research in every direction. Still there could only be one truth. The authors said they regarded their former experiments as essentially of a preliminary character. Unfortunately this was not the view others had been allowed to take, for the authors' past results had been quoted over and over again in proof of the existence of the β iron. They had indeed been the basis of the β theory of late. Now this basis had gone it seemed to him that the authors should not persist in believing that such a form of iron existed; in other words, their remarks that "the question of whether the β modification of iron plays the principal part in the hardening of steel is still an open one," surely fell to the ground. Again they stated: "It would thus appear either that there is no α heat relief or that the α and β crystal structures are identical." Then in the same paragraph they said that "the heat relief developed in the β range was identical with the α structure subsequently found by *etching the cold specimen*, etc." This last fact seemed absolutely to prove that the α and β iron of the authors were *one and the same thing*. So that after the large number of experiments they had carried out with so much mechanical skill without being able to find any difference in structure between the two forms, the authors ought to be satisfied that their previous theories were untenable. Whilst fully appreciating the excellent methods employed and the patient work of the authors in their research, it

seemed doubtful whether, as a whole, they could prove anything further beyond the experiments which had already been known many years ago with regard to the information obtained on the cooling curves of pure iron. With reference to the theory elaborated by the authors, with regard to the crystals of a pure metal being surrounded and cemented together by a very thin layer of the same metal in an amorphous condition, whose properties corresponded to those of the liquid metal to extreme undercooling, this seemed feasible. It might also be pointed out in connection with Dr. Carpenter's Paper that he found it necessary to remove the gases present from the electrolytic iron examined in order that the Ac_2 point was quite removed.

Mr. Humfrey said that the use of pure iron was given up, as when treated in vacua electrolytic iron got into an abnormal condition which could not be got over in any way; whereas iron containing a small amount of carbon was almost entirely free from this objection. Dr. Carpenter had based some of his criticisms on tables given in the Paper, but it would have been preferable to have taken the shape of the curve rather than to quote isolated figures from a table. Such a method was not a fair criticism of the work.

Dr. Rosenhain said the Paper had to be judged on its merits as a whole. It had been suggested that they had ignored the influence of a small percentage of carbon; he would point out that they had made certain experiments with electrolytic iron but they did not regard them as sufficiently satisfactory to lay before the Institute. He might state, however, that they got exactly the same amount of change of strength and structure as in the steel employed for the experiments in the Paper, and there was, therefore, some justification for the assumption that the influence of 0.1 per cent. carbon was very small. Experiments were now in progress on higher-carbon steels, and further results would be available in the future which would decide the point one way or the other. He claimed that their results proved that there was a mechanical discontinuity connected with the change from α to β iron. He was not prepared to admit that the α and β ranges were shown by the Paper to be identical. There were reasons which were very strong, based on the thermal investigation, to support discontinuity at that point.

The Critical Ranges of Cast Iron.

Professor Carpenter's Paper is given herewith in abstract:—

At the last meeting of the Iron and Steel Institute, a Paper was presented by Professor Carl Benedicks on "Allotropy in General, and that of Iron in Particular." With regard to the general question of allotrophy the author's conclusion was as follows: "The very common opinion that allotropy means a quite sudden transformation from one modification to the other, cannot, *a priori*, be maintained, except as a special case. . . . . There is always the possibility that one modification, or both modifications, have a certain solubility for each other—this is the simplest expression of the fact that the transformation partly takes place continuously. If the solubility were unlimited, an allotropic transformation point could not be spoken of in its defined sense; but allotropic modifications can nevertheless be said to occur."

Quite independently, Professor A. Smit had published a Paper during the previous year entitled "Eine neue Theorie der Erscheinung Allotropie," in which the view was put forward that "heterogeneous allotropy (two phases existing) always corresponds to the existence of homogeneous allotropy, or that in one and the same liquid or solid phase both modifications exist in a state of solution with a state of equilibrium which varies with the temperature. The allotropic transition points are regarded as being the splitting up of a homogeneous solid solution of the two modifications."

These theories, which have some experimental support, and have been carefully worked out, lead to very much, but not precisely the same conception of allotropic changes.

As regards the particular case of iron, Benedicks concluded that "a detailed examination of the physical knowledge of the critical transformation point A3 of iron at about 890 degs. C., and the lower more undecided transformation range A2, shows that the transformation of the iron at 890 degs. belongs to type IIa" (partial solubility of one modification in the other), "of which thus two examples are known. According to this, the nature of β-iron is to be α-iron, containing in solution a limited amount, increasing with the temperature, of γ-iron."

According to Benedicks' theory, pure iron above A3 consists only of γ molecules. At 890 degs. C. the great majority of these are transformed into α molecules; but the change is not completed until about 750 degs. C., below which temperature only α molecules exist. However, in replying to the discussion and communications on his Paper, Benedicks modified his interpretation of the above, being clearly influenced by Smit's theory of allotropy. He says: "At every temperature both α and γ molecules must be admitted as existing in equilibrium (in solution)." He therefore admits a certain solubility of α molecules in γ molecules above A3. The interpretation of Ar3 would then be a sudden displacement in the equilibrium proportions of α and γ, whereby the proportion of α is greatly increased. Even at A2, however, about 150 degs. below A3 the proportion of γ molecules is still considerable, and a further reduction of γ occurs at Ar2, below which its ratio to α is so small as to be negligible. Both interpretations, however, agree in regarding Ar2 as the extreme limit of supercooling of Ar3, and this comes to much the same thing as the view put forward by Osmond in 1890, viz.: "It seems probable, even if not certain, that Ar2 is only the end of Ar3 retarded by the presence of a little carbon."

Inasmuch as Benedicks' theory, if established, would constitute a more satisfactory solution of the differences existing among metallographers as to the allotropy of iron than any which had yet been published, the author decided to test it as crucially as possible.

From the author's experimental results and reasoning, the conclusion appears thoroughly warranted that the conception of A2 as an independent allotropic change must be abandoned, and it must now be regarded as proved that Ar2 is simply the termination of Ar3 retarded by impurities present even in the purest forms of iron hitherto prepared. The heating curves which constitute a crucial test of Benedicks' theory that β-iron is α-iron containing a limited amount of γ-iron in solution—the amount increasing with the temperature—have given results which are in complete accord with the requirements of that theory, that is, Ac2 cannot be detected in them. There is a perfectly reasonable explanation of the slight heat development or developments at Ar2, according as the curve has one or two peaks. This explanation is given in Professor Benedick's Paper. Moreover, Mr. Andrew's "degasified and almost carbonless iron" shows only the faintest indication of the Ar2 change. The conclusion, therefore, can scarcely be resisted that were it possible to remove the last traces of impurity, iron would cease to show even these faint indications of Ar2.

Dr. Rosenhain, in the course of the discussion on Professor Carpenter's Paper, said he was never an impassioned advocate of the Beta theory; he was not wedded to that or any other theory.

Professor Arnold indulged in numerous pleasantries on the subject of "The Burial of Beta," and gleefully remarked that they had assembled to inter "that threadbare old myth hard Beta iron," and by some irony of fate the gravediggers were named Rosenhain and Humfrey, while the officiating clergy were Drs. Carpenter and Stead. Criticising Dr. Carpenter's Paper (which he suggested ought really to have appeared under the joint name of Carpenter and Stead), he combated the assertion that the analysis of electro-

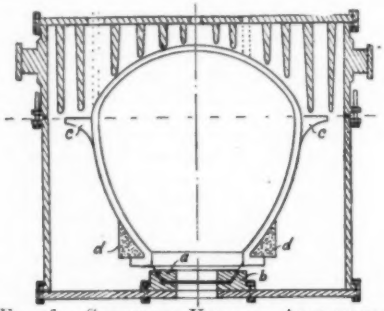

Fig. 1.—Sectional View of Assembled Mould.

lytic iron made by Professors Hicks and O'Shea was never published. It was published in 1897.

Professor Carpenter said that Professor Arnold had suggested that the Paper ought to have been submitted by Dr. Stead. He did not know what ground he had for making that suggestion. The work was done, and the Paper written, before Dr. Stead knew of it. It was a most improper suggestion to make. Another criticism was that he had

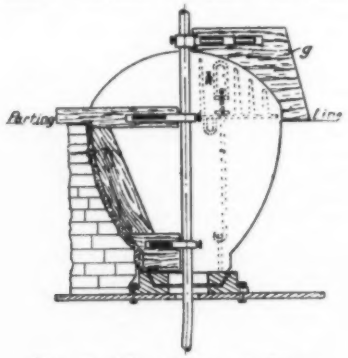

Fig. 2.—Building the Core.

omitted to give Hicks and O'Shea credit for analysis. Where the analysis was published he did not know.

Professor Arnold: In the commemoration book of Sheffield University College.

Professor Carpenter replied that the analysis in question was not published by Professors Hicks and O'Shea in their original research as presented before the British Association. That it had been published in any other quarter he had not been aware.

The Paper on "The Influence of Metalloids on the Properties of Cast Iron," which was taken as read, is published elsewhere in this issue.

Moulding Large Acid Pans in Loam.

By Dr. D. Watson.

The following is to illustrate the moulding of large acid pans in loam. With loam moulds there is generally a certain amount of tackle to make for each one. By this method more expenditure is required at the outset, but should there be two or three castings to make, there is eventual economy on the time saved in the moulding.

Fig. 1 is a sectional view of the assembled mould. The plates forming the box part can all be made in open sand. The cast-iron ring plates *a* and *b* form the seating for the core. Two off each of these are required, and they should be turned on the tapered face and fit well. With ordinary care this tackle will serve for any number of castings.

Two sweeping-up boards are needed for the outside of the mould. The cope is turned over, and each part is placed over a spindle centre. Special attention should be given to building, so that the one bricking will serve for several castings. The brackets *c* are formed by loose cores placed in when building. The cores *d* are placed in when the mould is dry.

Below the parting line (see Fig. 2) is a dummy mould. This is dried and given a coat of tar. The ring plate *a* is set in the seating *b*, and the core is built on it. The ring plate is lifted with the core by staples shown

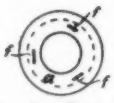

Fig. 3.—Ring for Bottom of Core.

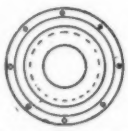

Fig. 4.—Seating Plate.

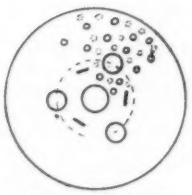

Fig. 5.—Crown Plate for Core.

at *f* in Fig. 3. When the core is built up to the parting line a crown plate, Fig. 5, is placed on. This is fastened down to the ring plate *a* by bolts and eyebolts (*h*, Fig. 2) are screwed on these for lifting the core. The core board *g* then comes into operation for sweeping the top of the core; when finished it should be left to stiffen before being lifted.

By means of this method the work can be subdivided to advantage, each moulder handling separate parts. With ordinary care the brick work will stand several casts, only requiring to be stripped and swept up each time. The box parts do away with the ramming round the outside of the mould, which is necessary with the ordinary loam mould. Special attention should be given to the building and fastening down of the core, in consequence of the enormous lift during casting.

The Clifton Iron and Steel Works, Coatbridge, of Wylie & Company, one of the companies amalgamated in the Scottish Iron and Steel Company, Limited, have been closed down. No definite information was given as to when the works would be restarted, but it is feared that they may be closed down for an indefinite period. The Coatbridge Ironworks of the same company have also been closed.

Some Further Notes on Moulding Sands.*

By J. Shaw.

I will first very briefly recapitulate the chief tests and conclusions embodied in a few recent Papers on moulding sands, and if any point is not quite clear the matter may be looked up in the originals. Most of those present, however, will be familiar with the points raised. Taking chemical analysis first; there are two methods, both of which have their advocates. If it be decided to use the ultimate analysis, it should be a complete one; and here let me call attention to an error I thought was long disposed of, viz., the idea that clay and alumina are the same thing. Yet at a Branch meeting of this Association recently, a speaker used them in the same sense.

Here before us we have a pure silica sand and a powdered clay substance. The latter, if pure (which the colour indicates it is not), would contain about 46 per cent. SiO_2, 40 per cent. Al_2O_3, and 14 per cent. combined water. Now an analysis of sand may be returned 85 per cent. SiO_2 and 5 per cent. Al_2O_3, etc. This does not mean that there is 85 per cent. of the first material and 5 per cent. of the clay substance, but leaving other minerals out of the question and reckoning the Al_2O_3 to be in the clay only, there is about 79 per cent. pure silica and about 12½ per cent. of the clay substance. This, I think, clears up one point.

There is now another factor. Two sands with the same alumina content give quite different results; one is quite a sharp sand, the other fit for making bricks. Here again there is a silicate of alumina (a brick) which, if crushed and added to the silica sand in the right proportion, would give the same chemical analysis, so far as concerns SiO_2 and Al_2O_3, as the first pair, but I need not state that no bonding power would be got from the latter pair if they were mixed all day, while from the first pair a good moulding sand would be got. This is the position of the alumina in the undecomposed felspar, etc. It must be quite evident now why the analysis must be a complete one, viz., to give some idea of the amount of fusible material and the amount of true clay substance.

Rational analysis is supposed to divide the sand into three substances, viz., quartz, clay, and felspar. Mr. Searle recently expressed warning against drawing conclusions from this method, and while thinking his condemnation too sweeping, no one will attempt to prove that the "rational" method is in any sense an accurate method, in that the sulphuric acid leaves some of the alumina in the clay substance undissolved and dissolves some of the alumina in the felspar and other minerals, and also since the constitution of both the clay substance and the felspar is assumed, and not proved. Notwithstanding these defects, I have no doubt in saying that a rational analysis of a sand, backed up with a few separate determinations for corrections, will repay the labour involved.

While the chemical analysis is useful, a study of the physical properties is more so. Taking fineness first; the sand should be as fine as possible to give a good skin to the casting, but the finer the sand the more easily is it fused, and the less permeable it is. Three methods of testing are given:—Sieve testing; testing by either the dry or wet method; and testing by means of "Schoene's" apparatus, to be described later. It will be remembered what great variation were shown in the sands I collected from the different shops in this country; but the coarser ones were milled, while the finest received little treatment. Porosity is not taken so much into account now. It is quite evident a sand may have a fair pore space, yet the passages for the gas to escape be so tortuous that escape is difficult.

Permeability, or the ease with which gases can pass through a sand, is of vital importance. This quality depends on a number of factors. The fineness of the sand, the hardness of ramming, and the clay content, all affect the permeability, while the fusing of the impurities at the surface of the mould is another point. Various tests have been put forward by various authors. Mr. Searle's test is open to two serious objections; no man can ram the same day after day, and if the metal box be retained, some mechanical means of ramming it should be designed to ensure a constant pressure. I also do not think a water test suitable, as both capillary action and the tendency of the steam to errode the passages in flowing are drawbacks.

Bonding Strength.—The strength of a sand is influenced by its moisture content, the pressure with which it is rammed, the size and shape of the particles, and the distribution of the bonding substance on the quartz, but chiefly by the pure clay substance. Several methods of direct testing are given in the recent Papers referred to above.

Refractoriness.—This is the quality of resistance to fusion at high temperatures, and depends to a great extent on the impurities present. Both quartz and clay are very refractory, but a combination of either or both, with the other minerals or coal dust, considerably reduces the sand's heat resistance. The most common test is to take a sample of the sand (Mr. Searle prefers to take only that portion which passes through a 150-mesh sieve), mix with a little dextrine and water, mould up into a pyramid about 2½ in. high and expose this to the heat of a test furnace side by side with Seger's cones of known fritting temperatures.

In addition to the foregoing summary of recent researches, the writer has at hand considerable information, collected from America and the Continent, that will probably be fresh to most of those present.

The American Foundrymen's Association some time ago appointed a committee to look into the question of moulding sands, and through the courtesy of Dr. Moldenke, I am able to put most of their findings before you, as well as several German Papers on the same subject. Requests for samples were sent out to both foundrymen and dealers, and in all 80 different samples were received, which, together with 12 samples of artificial sands, were submitted to tests.

The report opens with a chapter on the properties of minerals and the mineral constituents of moulding sands, giving the name, chemical composition and colour of the 38 minerals found in the samples. Colour is of importance as indicating the nature of the accessory minerals. The carbonates usually show a distinct cleavage and effervesce in hydrochloric acid,

* Paper presented before the Birmingham Branch of the British Foundrymen's Association, April 26, 1913. For previous Paper see Foundry Trade Journal, April, 1911.

Mica has a flaky, silvery appearance, and cleaves up into thin, flexible scales. The felspars are almost always partially altered to kaolinite, and appear as white clay-like lumps, which can easily be ground to powder. Olive green or bluish green colouring is usually due to the presence of ferro-magnesian minerals. Rusty yellow, reddish brown, and chocolate colours are due to iron oxides, which coat the sand grains, the brownish tints due to limonite and the red to hematite. The refractoriness of a sand

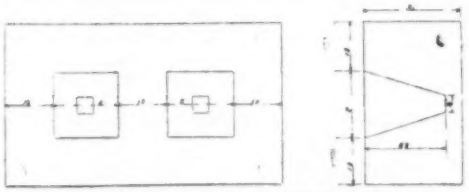

FIG. 1.—MOULD FOR REFRACTORY TESTING.

depends largely on its mineral content. While quartz, the principal constituent of moulding sands, melts at 1,600 deg. C., granite fuses at 1,240 deg. C., though quartz is one of its principal constituents. It is evident that some factor, aside from the melting points of the individual minerals, controls the fusion point of the mass.

Two conclusions may be drawn:—(1) No one can predict more than approximately the melting temperature of a sand by merely inspecting its mineral list. (2) The presence of easily fusible minerals is detrimental to a sand, especially if those minerals be basic fluxes, which will react with the quartz to form slag products.

No separate tests were made of refractory qualities of the sands sent in, but three German sands were tested by members of the German Association, and the melting points were found to be 1,630 deg. C., 1,520 deg. C., and 1,430 deg. C. The chemical analysis in percentages of the first was returned at:—SiO_2, 86.70; Al_2O_3, 4.20; Fe_2O_3, 3.95; CaO, 0.60; MgO, 0.90; alkalies, 1.30:—Loss on calcination, 2.30 (combined water, 1.45; CO_2, 0.76). The rational analysis was: Quartz, 78.40 per cent.; clay substance, 7.02; felspar, 7.54.

The method of testing I employ, is as follows:—Into a pattern 8½ in. by 5 in. by 3 in. thick, are cut two pyramids 2 in. square at the base to ¼ in. at the top and 2½ in. deep. These two pyramids are rammed with the sample sand. This is taken out, one portion mixed with coal dust, both sieved and the average fineness found. The two pyramids are again rammed up with the sieved sand, one with the coal dust mixture and one plain, and a complete mould made of the block and cast with good, hot iron. When cool, the casting is taken out, care being taken not to disturb the sand in the recesses, all other sand being brushed off. The sand from each pyramid is collected, and any decrease in the average fineness noted. By this means is obtained the degree of fritting action on the sand, and also the fritting action of the ash in the coal dust, which is often important.

I do not propose to say anything about the micro-petrological outfit and other apparatus used to distinguish the various minerals in sands, but would recommend anyone interested in this subject to study a small book on the subject, "Micro-petrology," by Rhodes.

A description of the method of making the test bars and the machines for testing same in the American investigation will be of interest. In order that you may better understand what follows, the results of a complete set of tests for one sand, noted B¹, are given herewith:—

MINERAL CONTENTS. SAND B1.

(1). Quartz, SiO_2.
(2). Microcline $(K,Na)\ AlSi_3O_8$.
(3). Limonite $2Fe_2O_3,3H_2O$.
(4). Muscovite $(K,Na)\ H_2Al_3\ (SiO_4)3$.
(5). Zircon, $ZrSiO_4$.
(6). Tourmaline, $Mg,Fe,Na_2Li_3,H_2,\ 9Al_2O_2Si_4,B_2O_{30}$.
(7). Magnetite, Fe_2O_3.
(8). Rutile, TiO_3.

Largest grains about 0.016". Most grains larger than 0.004" are roughly rounded. There is rather an abundant limonite coating The mineral dust is small.

Rational analysis:—Quartz, 68.77 per cent.; clay substance, 27.92 per cent.; felspar, 3.31 per cent.

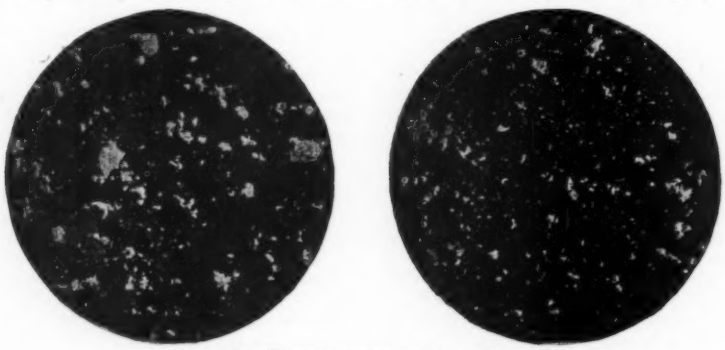

FIG. 2.—PHOTOMICROGRAPHS OF SAND B¹.

FINENESS.

Between mesh.	Per cent.
20 and 40	5.76
40 and 60	28.40
60 and 80	19.68
80 and 100	8.80
Over 100	37.36
Average fineness	68.72

TRANSVERSE STRENGTH.

Bars 1" sq. × 4½" long broken on supports 4" apart.

	lbs.
Dry	0.78
Water 5 %	0.48
Water 7.5 %	0.94
Water 10 %	0.38

CRUSHING STRENGTH.

Bars 1" sq. and 2½" high.

	lbs. per sq. in.
Dry	5.66
Water 5 %	9.51
Water 7.5 %	7.83
Water 10 %	6.65

PERMEABILITY TO AIR.

	Minutes for passage of defined quantity of air.
Dry	¾
Water 5 %	1
Water 7.5 %	1¼
Water 10 %	1¾

Clay bond by dye test:—Clay substance, 27.92 per cent.; dye absorbed, 99.11 per cent.; dye absorbed per unit of clay, 5.32 per cent.

Taking fineness first: after drying, the sand was passed through sieves of 20, 40, 60, 80 and 100 mesh, and an average fineness obtained by multiplying the quantity of sand retained on each size mesh by the number of the mesh previously passed through and dividing the totals by 100.

Retained on 40 = 5.76 × 20 (last mesh passed through)	115.20
Retained on 60 = 28.40 × 40 (last mesh passed t hrough)	1136.0
Retained on 80 = 19.68 × 60 (last mesh passed through)	1180.80
Retained on 100 = 8.80 × 80 (last mesh passed through)	704.00
Passed through 100 = 37.36 × 100	3736.00
100)	6872.00
Average fineness	68.72

tention is correct. Schoene's process is based on the knowledge that a definite flow of water is able to carry with it grains of sand up to a certain size. The following relation has been fixed between the rate of flow and the size of grain:—

0.2 Mm. per sec. flow corresponds to a grain size of under	0.01 Mm.
2.0 Mm. per sec. flow corresponds to a grain size of under	0.05 to 0.01 Mm.
7.0 Mm. per sec. flow corresponds to a grain size of under	0.10 to 0.05 Mm.
25.0 Mm. per sec. flow corresponds to a grain size of under	0.20 to 0.10 Mm

Fig. 3 shows the whole apparatus. The sand, after weighing, is placed in the conical portion. The flow is measured in the parallel part. The outlet is a small hole of 1.5 mm. at the bend of the graduated vertical tube. The tank A contains about two gallons

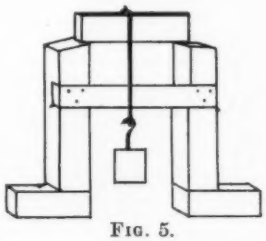

Fig. 5.

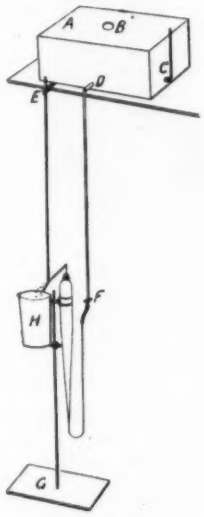

Fig. 3.

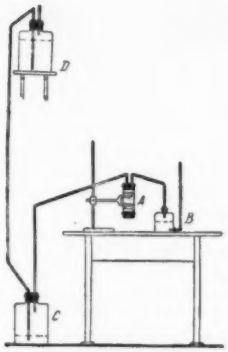

Fig. 8.

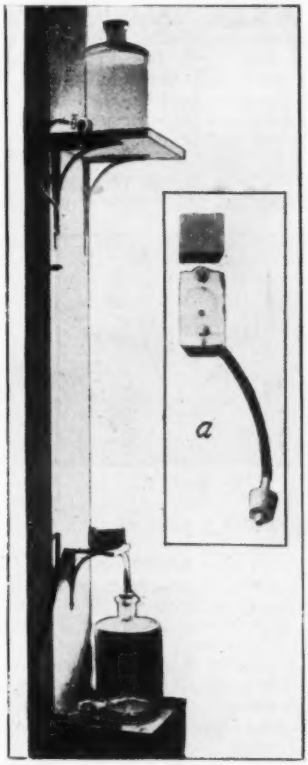

Fig. 7.

This method is mentioned by Mr. Mather, who suggests a modification, while Mr. Searle uses the "Jackson surface factor."

There is no mention of how the sieving was conducted, whether shaken for so long (as per Scott); but I find (and in this I am backed up by at least one leading expert) that the only way to get a true result is to shake until no more will come through. A sharp silica sand will sieve in a quarter the time a loamy sand takes.

In the German investigations Schoene's apparatus was used to separate the finer portions of a sand, it being contended that the mesh in the very fine sieves are not regular. If the fine sieves are passed under the microscope it will often be found that this contention is correct. Schoene's process is based on the knowledge that a definite flow of water is able to carry with it grains of sand up to a certain size. The following relation has been fixed between the rate of flow and the size of grain:—

of water. The flow is regulated by the tap F. It is quite evident that by opening the tap gradually, a time will come when the small opening will not cope with the stream of water, which then rises in the graduated tube and by its pressure increases the velocity of the overflow and therefore the flow through the whole apparatus. The instruments are calibrated before being sent out, and the heights marked on the graduated tube E to correspond with the various flows wanted. The sand which is carried over with each velocity is caught in separate breakers H, dried, weighed, and the percentage found.

In making the physical tests, each sand was tempered under as nearly identical conditions as possible.

Depending on the size of grain and the clay content, one sand might require more water than another to give best results. Three standards were fixed, viz., the addition to the perfectly dry sand of 5 per cent., 7½ per cent., 10 per cent. water. The first left the fine sands on the dry side, while 10 per cent. operated the other way on the coarse sands. The weighed dry sand was first spread on a concrete floor and the weighed amount of water was sprinkled on the sand a little at a time, and the sand well worked over. Each batch was put through a No. 8 riddle and left in an iron box, well covered up with a piece of wax cloth for about two hours to allow a thorough dissemination of the moisture.

The special flask shown in Fig. 4 was used for making the test bars. The sand was riddled into it, enough being used to cover the top about an inch. A hand rammer was next used rather gently on the sand, compressing the material to about ¼ in. over the mould, just as is done in moulding-machine practice, and the surplus struck off. Next the ¼-in. pieces of timber fitting into the compartments were laid on and the whole box and bottom board put under the letterpress and pressed flush. The flask being 1½ in. deep, the introduction of the ¼-in. pieces left the sand blocks 1 in. thick. Two boxes of bars were made from each sand and different moisture content, and formed enough test pieces to make at least two transverse, two crushing, and two permeability tests, and also a piece of each size after drying.

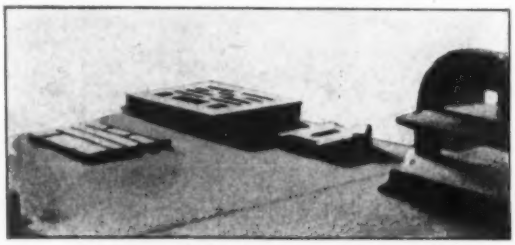

Fig. 4.

The bars for the transverse test (shown in Fig. 5) were made 4½ in. long and 1 in. square. These were placed on supports 4 in. apart. The load was applied in the centre. The knife edge placed on the bar of sand and the rod leading down to the buckets were of magnesium, while the bucket was of thin aluminium, to give the least weight possible. Bird-shot was very carefully put into the bucket until the bar failed, the weight including the knife edge, etc., was then taken and recorded in decimals of a lb. As the bar section was 1 in. square, therefore the results are in lbs. per sq. in. at 4-in. centres. The tests generally show that the coarse sands give the best result with 5 per cent. moisture, and the fine with 7½ to 10 per cent.

The crushing test pieces (Fig. 6) were 2½ in. long by 1 in. square. The illustration shows the manner of testing. The apparatus was substantially made of brass, the bucket being filled with large shot as required. Many of the dried samples were very strong, B^1 requiring 50 lbs. and O^3 60.3 lbs. to crush.

In order to determine the permeability of the sands, test pieces 2-in. square by 1-in. thick of each sand and various moisture content were made at the same time the other test pieces were made.

Fig. 7 shows the arrangement used. The sand block is shown clamped in the frame and connected with the pressure system, the water descending from the upper jar into the lower empty one drives one gallon of air through the tube and brass pipe of ¼-in. bore into the sand block, the entire front of which is practically unobstructed. When the sand is ready for clamping, the rear plate with the ¼-in. diameter hole, through which the air has to pass, is coated heavily with thick paint, so that the air may not escape along the surface. The block is put in position, the top plate put on, and the whole clamped sufficiently tight to make a good job. The apparatus is now set going; the water running down first compresses the air in the lower jar and gradually forces it through the sand. When the gallon of air has passed through, the test is stopped, the time noted, and the two jars reversed. The next test can then be made. It took just 5 minutes for the air to pass through when empty. The time taken for the air to pass through when the sand block was in position was noted and the 5 minutes deducted from the total time. The results are interesting and show how slight in some cases the obstruction of the sand really is, and also in a number of cases how the 10 per cent. water decreases the permeability, quite doubling the time. The head of water was 4 ft., about equal to 7 in. of molten metal.

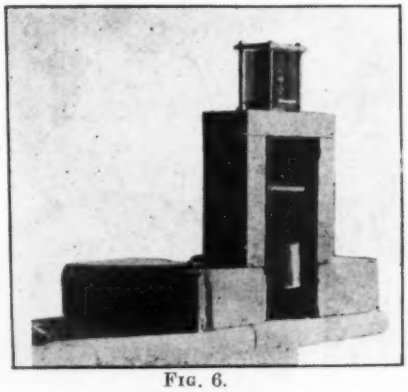

Fig. 6.

Fig. 8 shows a German method for the same test. The sand (100 c.c.m. is always taken) is placed in the cylinder A. This has a fine gauze at the bottom and is closed at the top with a rubber stopper having two openings, one of which leads to the air vessel C, the other to the manometer B containing water. The air is forced out of the air vessel by the stream of water from the upper vessel, and can only escape through the sand. The pressure necessary for the air to force its way through the sand is indicated by the manometer attached. The pressure alone is taken into account as indicating the permeability of the sand and not the time. Herr Holicky found permeability to be greater with sand in a moist condition; dry sand is close, and therefore less permeable. While this may hold good for the single sand he tried, many of the American results were opposite, and no doubt depend on the composition of the sand. He also states that if the sand is compressed by 10 per cent. of its height, the pressure of the manometer increases by over 100 per cent., showing how necessary it is to be careful with the rammer.

I have purposely left the remaining two tests till last. The rational analysis of each sand was determined, but no complete analysis. It was due to the non-concordant results in samples having practically the same fineness and clay content, that the last test was made.

About the only (and then not entirely satisfactory) method of determining the relative fatness or leanness of clays is their power to absorb dyes. The fatter the clay the more dye is absorbed. The following method was adopted:—Use 0.75 grammes of aniline green dissolved in 250 cc. of water and shake for five minutes. Add 50 grammes of the moulding sand and shake for ten minutes, then pour into a settling bottle. Let stand all night. Compare with standard solution of 0.75 grammes dye in 250 cc. water, shaken and let stand in the same way.

The strong sands could be detected at once by the comparatively light green colour of the water in the upper part of the bottle, while in the case of the weak sands it remained of almost the full strength of colour. The coloured water was put in one comparison tube and a measured quantity of the standard dye solution in another tube, side by side, and the latter diluted till the tints matched. The degree of dilution was then calculated and the percentage dye absorbed determined.

From the foregoing some conclusions may be drawn. Take the sample B[1] shown as typical of a number of sands that are puzzling. From the symbols for the chemical composition beside each mineral will be realised the chief weakness of "rational analysis." The fact is that all minerals soluble in boiling sulphuric acid and in caustic soda are returned in the rational analysis as "clay substance." In the case under discussion, the limonite, zircon, tourmaline, magnetite, rutile, and a little microcline and muscovite are included, and a glance at the chemical composition of these minerals will show that most of them have little to do with clay. At the same time, from the low return of "felspar," it is evident the microline is moderately decomposed to kaolinite. Even then, this would not account for the fairly high tests and good dye absorption. I am indebted to Mr. Searle for a suggestion on this point. He believes that the bond in this sand is not due so much to clay as to colloidal silica, which he finds to be a much more common constituent of sands than is generally supposed. Colloidal silica also absorbs dyes, and some vegetable matter in some sands will do the same. Some very pure quartz sands have a good bond due to colloidal silica, and contain less than 0.10 alumina. This theory would account for many seeming discrepancies.

In the tables I. and II. I have taken the five sands having the least transverse result and the five having the greatest transverse test. The crushing test follows the lead of the transverse test except U[1]. The dye test to some extent follows the same lead, but I must confess the permeability test is puzzling, and it is difficult to offer adequate reasons. You will notice the two least permeable are the finest and the coarsest sands. The fineness of the one and the large dye absorption of the other offer some reason.

I should like to have added the results of some of my experiments, but the Paper is quite long enough. Briefly, my idea was to mix an artificial sand as a standard. I took 88 per cent. of pure silica sand and ground it till all would pass through a 90-mesh sieve, discarded all fine that would pass through 150-mesh sieve, added 12 per cent. of good yellow plastic clay, which had been separated from all coarse material by washing and decantation. This latter material, when dry and powdered, would all pass through a 150-mesh sieve. The two materials were mixed together and 6 per cent. water sprayed on and the whole allowed to stand. Next day it was riddled, and with each mixing and riddling gained strength. As far as tried, it stood the action of hot metal, and was free from scabbing, with little venting.

TABLE I.—*Weak.*

	Trans.	Crush.	Perm.	Fin.	D.Ab.	Rat. Anal.		
						Q.	C.S.	F.
	Lbs.	Lbs.						
C1 ..	0.05	2.74	3	95.01	3.64	60.40	25.33	5.27
F6 ..	0.06	2.35	¾	45.27	2.68	45.77	24.23	30.00
G2 ..	0.06	1.76	1 1/16	64.50	2.90	56.91	21.36	21.73
H2 ..	0.02	2.08	⅝	88.37	3.90	78.03	18.28	3.69
M1 ..	0.06	1.64	1⅛	95.85	3.77	64.48	18.85	16.67

C-1

1. Quartz
2. Limonite
3. Tourmaline
4. Zircon
5. Magnetite
6. Serpentine
7. Microcline
8. Apatite

There are few grains larger than .004" and none show rounded edges due to travel The limonte content is average

F-6

1. Quartz
2. Garnet
3. Diopside
4. Hypersthene
5. Orthoclase
6. Plagioclase
7. Enstatite
8. Zircon
9. Limonite
10. Hornblende
11. Microcline
12. Magnetite
13. Kaolinite
14. Sericite
15. Chlorite
16. Apatite
17. Rutile

Largest grains .032" diameter. The larger grains are nearly all travel rounded Limonite content below average. Microperthite is present. Liquid and gas inclusions are abundant in the quartz The feldspars show little alteration

G-2

1. Quartz
2. Microcline
3. Garnet
4. Actinolite
5. Tremolite
6. Diopside
7. Plagioclase
8. Kaolinite
9. Zircon
10. Chlorite
11. Limonite
12. Magnetite
13. Sericite
14. Titanite
15. Apatite
16. Hematite
17. Sillimanite
18. Rutile

Diameter of largest grains .024"; most grains .004" and larger are well rounded. There is much mineral dust, which is largely quartz and kaolinite The limonite content is low

H-2

1. Quartz
2. Microcline
3. Orthoclase
4. Plagioclase
5. Tourmaline
6. Limonite
7. Muscovite
8. Kaolinite
9. Sericite
10. Magnetite
11. Zircon
12. Rutile

Largest grains .006" diameter. Shape of grains, subspherical to angular. Grains slightly smaller than .004" show rounding. Limonite content below average. Microperthite grains seen.

M-1

1. Quartz
2. Orthoclase
3. Plagioclase
4. Garnet
5. Hypersthene
6. Enstatite
7. Hornblende
8. Diopside
9. Limonite
10. Sericite
11. Kaolinite
12. Tourmaline
13. Zircon
14. Rutile
15. Chlorite
16. Titanite
17. Hematite

Largest grains .024" diameter. Many of the grains are nearly spherical in shape. Mineral dust below average. Limonite content less than average Microperthite grains considerably decomposed are present.

TABLE II.—*Strong.*

	Trans.	Crush.	Perm.	Fin.	D.Ab.	Rat. Anal.		
						Q.	C.S.	F
	Lbs.	Lbs.						
B6 ..	0.73	9.82	1	71.47	5.26	67.28	28.10	4.62
N1 ..	0.96	6.43	1	60.99	3.61	55.00	41.20	3.80
N3 ..	1.26	10.95	1	50.86	4.77	58.65	32.54	8.81
P1 ..	0.85	6.08	1	88.38	4.94	59.06	29.80	11.14
U1 ..	0.92	1.49	3½	36.88	8.88	88.70	8.85	2.45

B-6

1. Quartz
2. Limonite
3. Zircon
4. Tourmaline
5. Apatite
6. Magnetite
7. Sericite
8. Rutile

The largest grains are about .02" diameter. Rounding of the grains is not well developed. The limonite coating is above average.

N-1

1. Quartz
2. Limonite
3. Kaolinite
4. Magnetite
5. Sericite
6. Zircon
7. Apatite
8. Rutile
9. Monazite
10. Spinel

Largest grains about .036" diameter. Well-rounded grains are common. Limonite coating abundant. A greenish octahedral crystal of spinel was seen included in quartz.

N-3

1. Quartz
2. Limonite
3. Kaolinite
4. Enstatite
5. Microcline
6. Tourmaline
7. Magnetite
8. Zircon
9. Augite
10. Hematite
11. Apatite
12. Rutile

Largest grains .024" diameter. Well-rounded grains are common. Mineral dust low and limonite content above average.

P-1

1. Quartz
2. Limonite
3. Magnetite
4. Muscovite
5. Tourmaline
6. Kaolinite
7. Chlorite

Diameter of largest grains .024". Shape angular to roughly rounded Little mineral dust. Limonite content above average.

U-1

1. Quartz
2. Feldspars
3. Zircon
4. Kaolinite
5. Limonite
6. Magnetite
7. Chlorite
8. Apatite
9. Rutile
10. Hematite

A poorly assorted, coarse, gravelly sand with some grains over .12" diameter The shape of grain varies from angular to crudely rounded. Limonite coating average. Zircon inclusions in quartz were seen.

I also tried a mixture of fine silica sand with 8 per cent. colloidal silica, and obtained good results. I may say that colloidal silica is being used in Germany on a practical basis in renovating spent sand for green-sand work.

In conclusion, I wish to acknowledge help from Dr. Moldenke, Herr Holicky, and Mr. Searle.

Discussion.

MR. R. BUCHANAN wished to ask Mr. Shaw what he actually meant by a pore space. He himself was sometimes in doubt as to what was intended by the term—for instance, in regard to coke. Then Mr. Shaw had referred to colloidal silica. He (Mr. Buchanan) had heard the term before, but he did not know exactly what was meant by it. That this colloidal silica did have a binding action on the sand from the moulding point of view was, he thought, a very interesting fact. Then, he would like to hear what proof there was that coal-dust lowered the fusing point of sand. That was not quite in accordance with his (Mr. Buchanan's) views. He would also like to ask Mr. Shaw's opinion with regard to the influence of coal-dust in moulding sand as causing scabs or helping to stop scabbing. One man thought that coal-dust did prevent scabbing, and used to ram sand with coal-dust in it, round the runner, for that purpose. He did prove that anthracite coal-dust, which contained practically no free gases, undoubtedly caused scabbing.

MR. C. HEGGIE quite agreed with Mr. Shaw in reference to porosity; in fact, so far as he could see, the consideration of porosity had no real value, especially when the importance of permeability (which included porosity, plus something else) was emphasised. In reference to the penetration of the mould by the metal, irrespective of the temperature of the metal, he would like to ask Mr. Shaw if he would associate this with the property of permeability. One thing was clear, that no matter how complete the analysis, the microscope must always play an important part, as the size and shape of the grain effected, without exception, every property of the sand.

MR. H. PEMBERTON remarked that probably Mr. Shaw's use of aniline dyes in his investigation would be new to many of them. With regard to the porosity of sand, that was a subject which he thought was being taken up by some of the foundrymen nowadays. Unknowingly, perhaps, some of them were gradually throwing light upon porosity and the venting of the mould, because the two subjects seemed to come together. It used to be said of some sands that they required a tremendous lot of venting, because, without that venting, it was invariably found that the mould would scab. That defect had been somewhat eliminated by a different method of ramming up the mould, by having the mould rammed uniformly. Mr. Shaw had pointed out that no man could ram a mould two days the same. He quite agreed with Mr. Shaw in that, and he thought that the porosity of the sand had a relation to the ramming of the mould, though in what degree he was not prepared to say. It was well known what a lot of venting a mould for a tank plate would formerly have been given, but tank plates could be made without any venting at all if the sand was rammed uniformly by mechanical power. With regard to venting and porosity, he might say that only that day he was having an anvil block made, the mould for which was rammed by mechanical power. The bottom portion weighed about nine tons, and the anvil block about six tons, and the casting was made without any vents at all. That, he thought, spoke somewhat for the porosity of the sand and the evenness and uniformity of the ramming up of the mould. Mr. Shaw had spoken about the refractoriness of sand, and mentioned that in some tests he used dextrine to mix with the water. He (the speaker) would like to know what percentage was used in the samples shown, and whether the refractoriness was altered by using the dextrine. In regard to the samples made in the pyramid form, he thought it would be advisable to have mechanical ramming, so that they might know exactly the amount of power put on the press or ram before the sand was subjected to any test, whether crushing test or transverse test. Would Mr. Shaw tell them what percentage of coal dust he used, because if he could give that figure it might somewhat answer Mr. Buchanan's and his own questions with regard to the use of colloids in the sand in the sample that Mr. Shaw used in connection with the casting of the article, and the temperature of the metal. Mr. Shaw spoke about the fineness of the sand put through the various sieves, but he (Mr. Pemberton) thought that there was more to be said for the shape of the grains of the sand. He had used sands which practically had the same amount of alumina and the same fineness of grain, but one would not be so strong as the other, owing to the shape of the grains.

Mr. H. Winterton was sure that Mr. Shaw's work in regard to sands would lead other foundrymen to go further into what some might regard as the small items in connection with foundry work. In the same locality they would find some foundrymen getting their sands from one part of the country, and some from another, and making their choice for no other reason than that a certain sand had been recommended to them by somebody else.

Mr. Shaw, replying to the discussion, gave an explanation of what he meant by pore space. The specific gravity of the sand after drying at 100 deg. C. was found, then the volume weight was found. The difference between the two gave the ratio of pore space to sand. For instance, the specific gravity of the first German sand named was 2.542. The volume weight was 1.187; this gave a theoretical pore volume of 53.3 per cent. By dropping water into a dried sample of the sand it only took up 45 per cent. of water, due, probably, to the water not penetrating all parts properly before the sample collapsed. They must not, however, confound porosity with permeability. It was possible to have two sands with the same volume of pore space, one say a fine sand, with a large number of small twisting passages, making it most difficult for the gas to force its way out, and another a coarse sand with fewer but larger passages, making escape easy. Colloidal silica was a compound of silica and water in a gelatinous state, and was used in Germany as a renovator of spent sand, to renew the bond. He thought there was no doubt coal-dust reduced the melting point of a sand, as a test in a furnace would quickly prove, but in lower temperatures (say, cast iron), another factor came into play. When the molten metal came in contact with the facing sand, the volatile matter in the coal-dust was turned into a tarry gas, and the latter formed a cushion between the molten metal and the sand. This would account for the tendency to scab when anthracite was used as coal-dust, there being little volatile matter. This made the question of coal-dust a serious one. He thought he had answered Mr. Heggie's questions with that of Mr. Buchanan, except as regarded penetration. He did not think permeability had any thing to do with this property, but there was a searching action with some low-melting metals, such as lead, that was very puzzling. Mr. Pemberton had mentioned the use of dextrine in the refractory test. Its use did not affect the result in any way, but helped to hold the top of the pyramid together until a certain temperature was reached; also mechanical ramming was not necessary for this test. As to the percentage of coal-dust, one in eight was a fair average for medium work, but that, of course, depended on the size and shape of the casting to be made. He agreed that an irregular shape of grain would strengthen the sand and make it interlock, but there were very few sands in England which were not rounded; they were nearly all affected by river action. He thought the binding depended more on the clay.

American Malleable Cast Iron Record.

One of the open-hearth furnaces in the plant of the Pennsylvania Malleable Iron Company has made a remarkable record in the melting of iron for malleable castings. The furnace was placed in operation on September 27, 1909, after being generally repaired and the roof, bottom, etc., renewed, and was run continuously on white iron until July 2, 1911, up to which time it made 992 heats. After three days for cleaning the chequers, it was again operated up to November 2, 1912, making a total of 1,792 heats with an output of 26,880 tons. The furnace was then stopped for repairs, and was again put into operation on November 25, 1912, with the old bottom and roof. On March 29, the 210th heat was melted on the new run and the furnace was reported to be still in good condition.

Deoxidisers or Fluxes.

By Walter J. May.

To secure the greatest strength in a casting there must be absolute soundness and freedom from porosity and dirt. To get clean metal it must be melted in a proper crucible or furnace to just the necessary temperature for pouring, and the fuel used must be clean. Both underheating and overheating must be avoided, and the general conditions must be of the best. Further, the moulds must be clean and well made, the various sleeking materials being free from anything likely to affect the metal poured, and generally the moulding materials must be above reproach. With a man who understands melting, then, there should be no failures so far as the metal is concerned.

In many foundries, however, failures occur in regard to the metals, and usually such failures are traceable to something connected with the melting or the form of metal used. In cases where scrap is bought in for the foundry there is always room for trouble, sort and search the metal as much as one may. When such metal is used a cheap material is required to remove dirt and occluded gases; and this material should complete its cleaning action before the metal is poured, while not seriously affecting the character of the metal.

There is not any universal "flux" for all metals alike, and it is rather doubtful whether such a substance will be found, but there are substances or combinations of substances which will ensure soundness and cleanliness of the metals used for castings without seriously altering the metal, and these, properly used, would not cost more than a halfpenny per cwt. of the metal poured, while in most cases a farthing per cwt. of molten metal would be the cost.

Generally, in an iron foundry, ferro-aluminium, ferro-silicon, or ferro-manganese will, if properly used, secure soundness, but at a higher cost than that named above, while for brass and bronze either aluminium or chloride of zinc in a dry state will clean the metal and ensure clean castings, and, if not used to excess, none of these things will injure or seriously alter the metal. Too much should not be applied, however, because it is possible to make considerable changes in the metals by using these additions. Chloride of zinc can also be used with aluminium as well as copper alloys, provided only from one to three ounces of the dry salt is stirred into the metal, according to its quality.

There is no reason at all why every casting turned out from the foundry should not be sound and clean, and the people who turn out faulty work are entirely to blame in the matter.

Rustproof Coating for Iron Patterns.

According to a writer in the "American Machinist," a simple method for preventing the rusting of iron patterns is to give them a coat of beeswax, which also makes the patterns leave the sand more freely. It is stated that the wax will adhere better if the pattern is a little rusty and it is well to let it rust before applying the wax. To those who have studied the mechanism of corrosion, however, this latter advice will wear a doubtful aspect; although it will be agreed that the pattern should be heated just enough to melt the wax when applied. The wax should be rubbed all over the pattern with a brush to fill up the holes, etc., and the surplus then removed and the pattern left in a cool place until perfectly cold. It is best to rub the pattern with a stiff bristle brush to make it smooth and glossy. Large patterns can be warmed up in a core oven before applying the wax.

The Influence of the Metalloids on the Properties of Cast Iron.

By H. I. Coe, M.Sc. (University of Birmingham).

The present research is intended as preliminary to one dealing with the effect of metals not usually present in cast iron on the iron carbon alloys, in order subsequently to ascertain by comparison the utility of adding those metals to cast iron.

The general scheme of work involved an investigation of the effect of varying quantities of manganese, sulphur, and phosphorus on cast irons containing different proportions of silicon. The influence of varying total carbon was not considered, and it was endeavoured to keep that element as constant as possible, in the region of 3 per cent., though complete success in this direction was not attained owing to the diluting action of the ferro-silicon employed. The base used was American washed iron, which was melted under charcoal in a graphite crucible, and when melted the other elements were added in the form of suitable alloys.

Transverse bars 15 in. by 1 in. by 1 in. (tested on 12-in. centres), and 9-in. tensile bars, 6 in. of which had a diameter of ¾ in., were prepared. Since many of the bars were too hard to machine, all were tested as cast. The hardness, as determined by the scleroscope, often varied very considerably from the exterior to the interior. In order, therefore, to get relative results the hardness values were in all cases obtained from the polished surfaces of the transverse bars; their actual value will have to be considered in connection with the remarks in Table I.

The Influence of Silicon on Cast Iron.

The influence of silicon on the condition of the carbon will be seen upon reference to Table I. Broadly, the results are in agreement with those given in recent papers by Hatfield, and by Hague and Turner, though the conditions as regards size of bar and total carbon content were slightly different, both factors tending to an increased separation of graphite in the present series. With the increasing separation of graphite the strength and hardness of the bars decreases, while the deflection fluctuates somewhat irregularly.

The Influence of Manganese on Cast Iron in the Presence of Silicon.

The influence of manganese on pure iron-carbon alloys has been investigated by Wüst, by the author, and others, and it has been shown that in such cases the addition of manganese increases the stability of the carbide owing to the formation of a double carbide of iron and manganese, which does not readily decompose; a direct hardening effect is also observed.

In the presence of 2 or 3 per cent. of silicon the effect is similar, though not so pronounced; the hardness is considerably increased, and the general effect of the addition of large quantities of manganese is to retain the carbon in the combined form.

A point of very considerable importance was observed by A. Hague and T. Turner relative to the influence of a small quantity of manganese on a siliceous cast iron. 0.6 per cent. of manganese added to a cast iron containing 3 per cent. of silicon resulted in a considerable decrease in the percentage of combined carbon.

The author investigated this point more fully, the results of the research being embodied in a Paper to the British Foundrymen's Association. It was found that the addition of manganese to a cast iron containing 2 per cent. of silicon, either in the presence or absence of phosphorus, resulted in a diminution of the percentage of combined carbon, with a corresponding decrease in hardness, this effect reaching a maximum with 0.5 per cent. of manganese; further addition of manganese was accompanied by an increased percentage of combined carbon and increased hardness.

The cast irons examined in the present research were prepared in a different manner from those described above, but nevertheless, the facts observed are in substantial agreement.

In discussing the influence of manganese there is another factor to consider, namely, rate of cooling. The fracture and the microstructure show that the chilling action of the sand is intensified by even small additions of manganese. The softening influence of the manganese is, however, observed on the unchilled interior of the bar.

This softening influence of small quantities of manganese on siliceous irons is due to the precipitation of secondary graphite after solidification down to the pearlite arrest point; evidence for this statement is found in shrinkage curves and photomicrographs that have been published.

Reference to Table I. shows that the addition of small quantities of manganese considerably increases the strength and deflection, the effect being more marked in those irons which in the ordinary cast condition are wholly grey. In the latter irons, also, the hardness is seen to fall with the addition of 0.5 per cent. manganese, and then to increase with further addition. It will be observed that while the hardness varies with the combined carbon, the strength is more influenced by change in structure.

The Influence of Sulphur on Cast Iron containing Silicon.

The subject of the influence of sulphur on cast iron has attracted considerable attention of late years, and important researches dealing with it have been published, notably by J. E. Stead and D. M. Levy.

Dr. Percy, in discussing work performed in his laboratory on the influence of sulphur on cast iron, states that "sulphur in certain proportions has the power of causing carbon to remain in the combined state during solidification after fusion." This statement has been fully confirmed by later investigators.

At the same time, comparatively little is known of the effect of sulphur on the mechanical properties of cast iron, other than that it hardens the metal owing to its influence on the state of the carbon. Again, the general opinion is held that it renders cast iron brittle, though the author knows that some foundry managers realise the value of suitable proportions of sulphur in increasing the valuable mechanical properties of cast iron.

Reference to the figures given in Table I. shows the influence of small additions of sulphur on the

mechanical and chemical properties. The author has already discussed most of the results given in this portion of the Table in a Paper entitled "Sulphur in Cast Iron," read before the British Foundrymen's Association, so that only brief reference to it is required here. The outstanding features may be summarised as follows:—

(1) The influence of sulphur on the condition of the carbon is dependent to a considerable extent on the percentage of silicon; with a low silicon content the addition of mere traces of sulphur is sufficient to throw the greater part of the carbon into the combined form in the conditions under which the bars were cast, while with a higher silicon content appreciable additions of sulphur may be made without any considerable change in the condition of the carbon. The hardness of the bars is largely a function of the combined carbon.

(2) The strength of the bars increases in a remarkable manner with the increase in sulphur content, especially in the case of the bars which are wholly grey. Bar 37, which has the high tensile strength of 21.2 tons per sq. in., associated with high transverse strength and deflection, was too hard to be machined easily with ordinary tools, though it would be serviceable where small, strong castings were required. It is probable that the increased strength of the bars is due to the effect of sulphur in modifying the dendritic structure of the irons, and on the fineness of the graphite, more than to its effect on the condition of the carbon. Rough tests with a hammer showed no indication of brittleness due to sulphur.

(3) Manganese in the proportions required to form MnS practically neutralises the normal influence of sulphur on the condition of the carbon, and in excess it tends to the elimination of sulphur owing to the

TABLE I.

	No.	Transverse Strength, 12" x 1" x 1", Cwts.	Deflection, Inches.	Tensile Strength, Tons per sq. in.	Hardness Number.	Total Carbon, Per Cent.	Graphitic Carbon, Per Cent.	Combined Carbon, Per Cent.	Silicon, Per Cent.	Manganese, Per Cent.	Sulphur, Per Cent.	Phosphorus, Per Cent.	Remarks on the Fracture.
Silicon	1	29·4	0·084	12·95	57	3·22	0·03	3·19	0·40	...	0·011	0·018	White and crystalline.
	2	29·1	0·093	13·72	56·5	3·12	0·25	2·87	0·50	..	...	...	Slight central mottle.
	3	25·3	0·100	10·06	58	3·04	1·77	1·27	0·80	...	0·013	...	White edges.
	4	21·4	0·094	12·67	47	3·28	2·15	1·13	1·00	0·014	..	0·090	Narrow white edges.
	5	22·0	0·098	9·03	49	2·80	1·61	1·19	1·11	...	...	...	Very slight chill.
	6	23·5	0·102	9·03	47	3·05	1·95	1·10	1·31	...	0·011	...	.. ..
	7	23·8	0·132	10·10	43	3·02	2·10	0·92	1·62	0·040	0·015	0·093	Light grey.
	8	24·6	0·115	...	...	3·05	2·05	1·00	1·87	...	...	..	..
	9	23·8	0·080	14·33	40·5	2·88	1·80	1·08	2·03	0·020	...	...	More open grain.
	10	20·0	0·060	9·02	45	2·79	1·73	1·06	2·24	0·016	0·016	0·027	.. .. ..
Manganese.	11	29·8	0·080	...	59·7	3·08	0·46	2·62	0·58	0·784	.	...	White and crystalline.
	12	34·7	0·093	15·50	58	3·22	1·09	2·13	0·82	0·350	...	...	Mottled centre.
	4	24·4	0·094	12·67	47	3·28	2·15	1·13	1·00	0·014	...	0·090	Narrow white edges.
	13	32·0	0·098	13·28	50	3·30	2·25	1·05	1·00	0·050	...	...	.. ..
	14	30·9	0·092	16·59	51·5	3·15	2·33	0·82	1·02	0·846	...	..	.. ..
	15	33·0	0·103	16·35	65·5	3·08	1·07	2·01	1·03	2·000	...	...	White and crystalline.
	7	23·8	0·132	10·10	43	3·02	2·10	0·92	1·62	0·040	0·015	0·093	Light grey.
	16	24·0	0·132	14·05	31	3·19	2·89	0·30	1·52	0·541	. .	0·027	Dark velvety grey.
	17	27·1	0·110	15·11	40	3·04	2·61	0·43	1·50	1·030	...	..	Corners white.
	18	28·2	0·148	18·16	42·5	3·20	2·42	0·78	1·69	2·220	..	...	Silvery grey.
	10	20·0	0·080	9·02	45	2·79	1·73	1·06	2·24	0·016	0·016	0·027	Light grey and open.
	19	20·8	0·133	12·12	31	3·05	2·83	0·22	2·25	0·611	...	...	Dark grey and close.
	20	21·6	0·129	15·48	38	3·11	2·64	0·47	2·29	1·023		...	Somewhat lighter.
	21	28·6	0·120	15·47	43	3·03	2·34	0·69	2·42	1·900	..	...	.. ..
Sulphur.	3	25·3	0·100	10·06	58	3·04	1·77	1·27	0·80	..	0·013	...	White edges.
	22			10·46	59	3·06	0·26	2·80	0·80	.	0·034	..	White, slight mottle.
	23	35·4	0·114	...	60	3·13	0·33	2·80	0·78	...	0·060	...	.. ..
	24	39·6	0·129	10·18	58	3·09	0·33	2·67	0·82	...	0·103	...	.. ..
	6	23·5	0·102	9·03	47	3·05	1·95	1·10	1·31	...	0·011	.	Slight chill.
	25	32·5	0·116	13·28	50	3·16	1·45	1·71	1·35	...	0·050	...	Considerable chill.
	26	42·0	0·127	...	56	3·09	0·80	2·29	1·30	..	0·105	...	White, slight mottle.
	27	35·6	0·122		56	2·94	0·50	2·44	1·32	..	0·150		.. ..
	28	39·6	0·122	13·05	61	2·91	0·40	2·51	1·17	...	0·193	...	Only centre mottled.
	7	23·8	0·132	10·10	43	3·02	2·10	0·92	1·62	0·04	0·015	0·093	Light grey.
	29	24·1	0·118	15·84	43	3·12	2·12	1·00	1·00	..	0·031	..	..
	30	30·2	0·120	14·28	43	2·90	1·75	1·15	1·63	..	0·056	..	..
	31	30·7	0·126	...	40	3·02	1·80	1·22	1·40	..	0·084	..	Corners chilled.
	32	28·9	0·127	8·84	43	3·09	1·95	1·14	1·57	..	0·090	..	..
	33	26·7	0·096	14·50	49	2·94	1·09	1·25	1·52	...	0·103	..	Edges chilled.
	34	28·5	0·102	18·48	60	3·05	1·80	1·25	1·69	.	0·112	..	..
	35	30·5	0·090	12·24	60	2·87	0·67	2·20	1·55	...	0·155	..	White, mottled centre.
	10	20·0	0·080	9·02	45	2·79	1·73	1·06	2·24	0·016	0·016	0·027	Light grey, open.
	36	27·9	0·114	13·04	45	2·90	1·84	1·06	2·24	...	0·104	.	..
	37	35·7	0·150	19·71*	43	2·70	1·57	1·13	2·37	...	0·180	...	..
	38	31·8	0·106	16·61	63	2·70	0·85	1·85	2·05	...	0·452	...	White edges, grey centre.
	39	27·3	0·097	12·61	53	2·90	1·57	1·33	1·23	0·325	0·204	...	Chilled edges.
	40	29·0	0·125	14·90	44	3·06	2·34	0·72	1·05	0·857	0·027	...	Grey.
Phosphorus.	4	24·4	0·094	12·67	47	3·28	2·15	1·13	1·00	0·014	...	0·090	Narrow white edge.
	41	21·2	0·093	13·20	40·5	3·24	2·05	1·19	1·05	...	...	0·406	Uniform open grey.
	42	25·0	0·118	15·30	43	3·19	2·19	1·00	1·03	...	...	0·810	Closer grain.
	43	22·1	0·074	12·50	62	2·48	0·90	1·58	1·05	...	...	2·000	Whitish tinged grey.
	7	23·8	0·132	10·10	43	3·02	2·10	0·92	1·62	0·040	0·015	0·093	Light grey.
	44	26·1	0·128	14·90	37·5	3·03	2·14	0·89	1·62	...	...	0·400	Later grey.
	45	27·7	0·119	...	37	3·05	2·17	0·88	1·40	...	...	0·620	..
	46	27·2	0·123	15·56	40	3·01	2·14	0·87	1·58	..	..	0·755	..
	47	24·4	0·090	7·68	48	2·77	1·63	1·14	1·40	..	..	1·225	..
	48	18·9	0·073	11·39	54	2·41	1·03	1·38	1·59	...	...	1·745	Mottled grey.
	9	23·8	0·080	14·33	40·5	2·88	1·80	1·08	2·03	0·020	...	0·040	Light grey, open.
	49	26·3	0·121	15·10	40	2·83	1·78	1·05	2·05	.	..	0·512	Speckled grey.
	50	22·4	0·109	5·65	40·5	2·64	1·56	1·08	2·34	.	..	0·980	.. paler.
	51	24·1		12·10	43	2·46	1·39	1·27	2·00	.	..	1·100	.. ..
	52	19·7	0·080	10·87	52·5	2·26	1·11	1·15	2·46	...	...	1·850	.. ..
	53	16·6	0·050	11·10	58	2·23	0·92	1·33	2·08	...	...	2·246	.. ..
	54	26·4	0·056	7·93	62·5	2·42	1·33	1·09	2·00	...	...	2·880	Glazed appearance.

* Broke in shoulder. Turned down to ½ in. and retested, broke at 21·2 tons per sq. in.

separation of manganese sulphide from the fluid cast iron before solidification commences. The mixture made up for Bar 40 was equivalent to 1.2 per cent. manganese and 0.2 per cent. sulphur.

(4) There was no evidence in the experiments described to show that high sulphur content results in the formation of blow-holes.

The Influence of Phosphorus on Cast Iron containing Silicon.

The influence of phosphorus on the condition of the carbon in siliceous irons is shown in Table I. Addi-

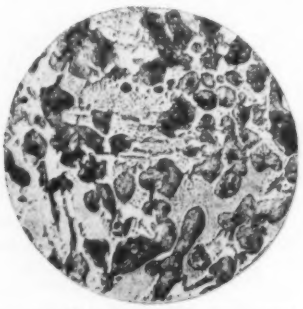

FIG. 1.—BAR 1. 0.42 PER CENT. SILICON. (MAGNIFIED 70 DIAMETERS.)

tions up to 1 per cent. have comparatively little effect, appearing slightly to diminish the percentage of combined carbon and to decrease the hardness, but larger quantities cause the retention of an increased percentage of carbon in the combined form. It is possible that two influences are at work: on the one hand, the tendency of phosphorus to retain iron carbide as the third constituent of a triple eutectic, and, on the other hand, the tendency to the formation of graphite owing to the metal remaining in the fluid or semi-fluid condition for a longer time by reason

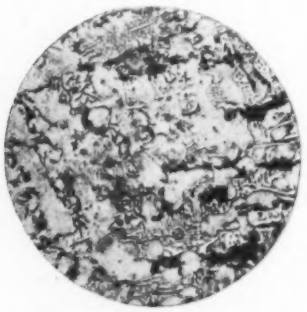

FIG. 2.—BAR 3. 0.80 PER CENT. SILICON. (MAGNIFIED 70 DIAMETERS.)

of the presence of phosphorus. With small percentages of phosphorus only, the latter factor more than balances the tendency of phosphorus to retain the carbon in the combined form.

The chilling action of the sand in irons low in silicon is not nearly so marked in the presence of phosphorus. The addition of about 1 per cent. of phosphorus appears to strengthen cast iron, but the addition of 2 per cent. results in a hard, weak, brittle material possessing low deflection.

The Microstructure of the Cast Irons.

The microstructure in general bears out the change in the condition of the carbon as shown by the analysis. Fig. 1 shows that the microstructure of Bar 1, 0.4 per cent. silicon, is identical with that of pure white iron containing about 3 per cent. of carbon. Further addition of silicon results in the partial breakdown of the iron carbide, as is illustrated by the microstructure of Bar 3, 0.8 per cent. silicon (Fig. 2). Fig. 3 shows that complete decomposition of all free iron carbide has taken place with the addition of 1.6 per cent. silicon. The specimen was not etched, and

FIG. 3.—BAR 7. 1.62 PER CENT. SILICON. UNETCHED. (MAGNIFIED 70 DIAMETERS.)

the photograph shows very clearly the marked dendritic form of the primary crystals, and also the replacement of the iron carbide-pearlite eutectic by one of graphite and pearlite. Whether this graphite-pearlite complex is a true eutectic is a matter for discussion. The pearlite (the result of the decomposition of austenite in the neighbourhood of 700 degs. C.) is better developed in the irons that are mottled or white than in those that are grey.

It may be repeated here that any diminution in the pronounced dendritic structure of the cast irons is accompanied by an increase in strength, and that the

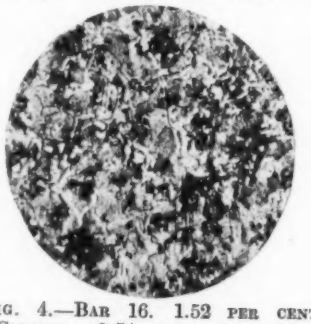

FIG. 4.—BAR 16. 1.52 PER CENT. SILICON; 0.54 PER CENT. MANGANESE. (MAGNIFIED 70 DIAMETERS.)

influence of sulphur in increasing the strength of cast iron is largely due to this action.

Further addition of silicon within the limits of the experiments described is not accompanied by any change in the microstructure.

Manganese in small quantity (0.5 per cent.) added to grey irons results in the replacement of part of the pearlitic ground-mass by ferrite (Fig. 4), thus bearing out remarks made in discussing the effect

of manganese on the condition of the carbon and the hardness of the bars.

Fig. 5 illustrates the influence of a considerable addition of sulphur to an iron containing 1.55 per cent. silicon; in the absence of sulphur the iron carbide areas are absent. Fig. 6 is interesting since it illustrates a structure under low power, which has been shown to be characteristic of cast irons possessing considerable strength; further, it points to an in-

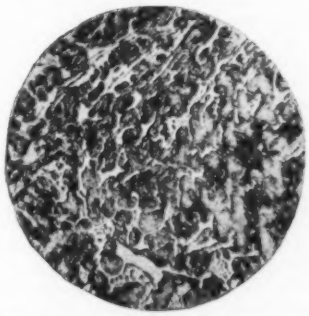

FIG. 5.—BAR 35. 1.55 PER CENT. SILICON; 0.15 PER CENT. SULPHUR. (MAGNIFIED 70 DIAMETERS.)

teresting sequence in the solidification of the metal, grey areas consisting of pearlite and graphite being surrounded by a network of the iron carbide-pearlite eutectic, which solidifies last.

The blobs of yellow-brown iron sulphide, FeS, in the grey irons of the series were found towards the boundaries of the primary crystals, while in the mottled and white irons the greater portion of the iron sulphide was observed in association with the iron carbide-pearlite eutectic.

The addition of phosphorus results, as is well known, in the formation of a eutectic, the nature of which varies according to the amount of other impurities present in the cast iron. Fig. 7 of Bar 46, 1.6 per

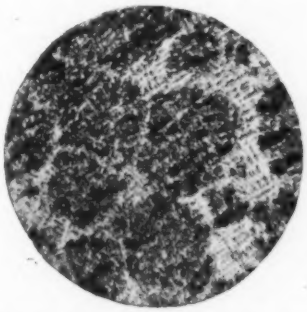

FIG. 6.—BAR 34. 1.69 PER CENT. SILICON; 0.11 PER CENT. SULPHUR. (MAGNIFIED 26 DIAMETERS.)

cent. silicon, 0.75 per cent. phosphorus, shows the normal form of phosphide eutectic together with flakes of graphite embedded in a ground-mass of pearlite. There are apparently three stages in the solidification of such an iron: (1) the separation of primary austenite crystals, followed by (2) a separation of graphite, and afterwards by (3) the solidification of the eutectic.

Fig. 8 (Bar 48, 1.6 per cent. silicon, 1.95 per cent. phosphorus, heat tinted), shows a considerable change in the character of the eutectic, which now appears to consist of three constituents—iron carbide, tinted darkest; iron phosphide, slightly lighter; and pearlite, which make up a ternary eutectic. The rectilinear crystallisation of the iron carbide is well displayed in Fig. 9, a photograph of the same iron; it explains the brittleness of these cast irons, since these thin plates of hard, brittle material form lines of weakness along which fracture easily takes place.

Pyrometric Results.

An investigation was made of the influence of the metalloids on the temperature of pearlite formation, and results were obtained in accordance with those that have already been published, namely, that silicon raises the temperature of pearlite formation by some 25 degs. C. for each per cent. added, while the addition of 1 per cent. of manganese depresses that point by the same number of degrees.

Complete cooling curves of a number of phosphoric irons were taken; 450 grammes each of Bars 9, 49, 50, 51, 53, 54, containing about 2 per cent. of silicon, and up to 2.8 per cent. of phosphorus, were melted in a gas-injector furnace and readings taken during

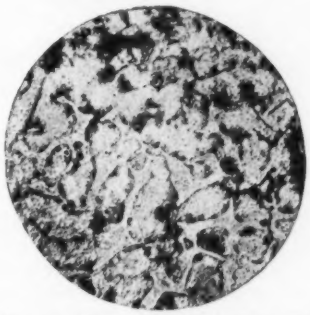

FIG. 7.—BAR 46. 1.58 PER CENT. SILICON; 0.75 PER CENT. PHOSPHORUS. (MAGNIFIED 114 DIAMETERS.)

cooling on a thermocouple potentiometer. The composition of the buttons obtained was as follows:—

	A.*	B.	C.	D.	E.*	F
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Total carbon	2.71	2.82	2.60	2.68	2.20	2.38
Graphitic carbon ..	2.54	2.08	1.55	1.60	1.50	1.31
Combined carbon ..	0.17	0.74	1.05	1.08	0.70	1.07
Silicon	2.01	2.09	2.17	1.81	1.83	1.85
Phosphorus	0.09	0.53	1.01	1.23	2.16	2.90

* Reheated to about 940° C. and cooled slowly.

The curves drawn in Fig. 10 show a number of interesting arrest points. The temperature of initial solidification is lowered, at first slightly, then more rapidly, with over 2 per cent. of phosphorus. The same statement holds good for the second arrest point, except that the effect is more marked; the intensity of this arrest diminishes with increase in phosphorus.

The third arrest point in those melts containing phosphorus is due to the solidification at about 930 degs. C. of a phosphide eutectic; the intensity of this arrest increases with the increase in phosphorus content, which also raises the actual temperature at which solidification takes place.

The fourth arrest point, due to the formation of pearlite, does not appear to be influenced by the addition of phosphorus.

In melts E and F a slight arrest was observed at 720 degs. C. which may be due, as suggested by Dr Stead, to the formation of pearlite from the austenite of the ternary eutectic.

The assistance of the microscope is required in the interpretation of these various arrest points on the cooling curves, and the remarks made in discussing the microstructure of the bars will be sufficient to explain the arrests.

A reference to the shrinkage curve of a phosphoric iron given by Professor T. Turner in his Paper on the

FIG. 8.—BAR 48. 1.59 PER CENT. SILICON; 1.75 PER CENT. PHOSPHORUS. HEAT TINTED. (MAGNIFIED 105 DIAMETERS.)

"Volume and Temperature Changes during the Cooling of Cast Iron," in 1906, will be instructive in this connection.

Finally, with regard to the formation of graphite in cast irons, there was strong evidence in many cases of the preliminary separation of carbide of iron, followed by its decomposition with the liberation of graphite. In a section, part of which is shown in Fig. 2, the complete sequence could easily be followed.

Undecomposed areas of eutectic were associated with others in which part of the iron carbide had just decomposed before complete solidification took place; mere spots or very small flakes of graphite had

FIG. 9.—BAR 48. 1.59 PER CENT. SILICON; 1.75 PER CENT. PHOSPHORUS. HEAT TINTED. (MAGNIFIED 140 DIAMETERS.)

formed, but nearer the centre of the bar, which remained fluid rather longer, long flakes had formed by the linking up of these spots or smaller flakes.

Summary.

Silicon decreases the strength and hardness of cast iron owing to its effect in promoting the decomposition of iron carbide.

Manganese to the extent of 0.5 per cent. results in a considerable softening of siliceous grey irons, owing to its effect on the condition of the carbon; the strength is increased by the addition of manganese.

The influence of sulphur is largely determined by the percentage of silicon present. Carefully controlled, it should be of considerable value to the ironfounder in mixing his irons for any particular purpose.

In the absence of manganese, and in the presence of about 2 per cent. of silicon, very strong grey cast irons may be obtained if the percentage of sulphur be judiciously raised.

Phosphorus to the extent of about 1 per cent. is useful, since it confers fluidity upon cast iron, slightly increases the strength, and also slightly diminishes the hardness of the metal. A higher percentage results, however, in a hard brittle material.

Discussion.

MR. E. ADAMSON (Sheffield) handed in the following written contribution to the discussion:—The author is to be congratulated upon his Paper, and more particularly on his conclusions with regard to the influence of sulphur and phosphorus. It is hoped these conclusions will assist in removing the unnecessary demand in chemical specifications for low sulphur in foundry irons, and also do some little to establish the fact, well-known in

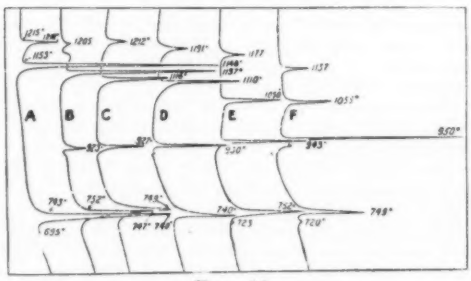

FIG. 10.

the iron foundry, that high-phosphorus irons can, and do, regularly give high mechanical tests. Both of these facts have on several occasions during recent years been brought by me before technical institutes, apparently without any result in altering the opinions of those who insist on the primary importance of chemical composition. Now, however, there is hope. With regard to sulphur, this was strongly taken up by me in a discussion before the Cleveland engineers in March, 1907, also in my Papers of November, 1906, and February, 1909, in the latter of which were given figures of high tests with iron containing high sulphur. With regard to phosphorus, it was clearly demonstrated in the Paper given before the Iron and Steel Institute in October, 1909, that a better transverse test was obtained with phosphorus 1.20 per cent. than 0.80 per cent. Mr. Coe's tests are not from works practice, whilst mine were, and his results confirm mine. There are, however, a few points upon which Mr. Coe's conclusions do not appear to be quite correct; but it is satisfactory to note he has given the fracture of his samples, as this is of the greatest importance to the man who is actually using iron for high-class castings. In his summary Mr. Coe states that "silicon decreases the strength and hardness of cast iron, owing to its effect in promoting a decomposition of the iron carbide." Mr. Coe appears to draw

conclusions from his own tests, but ignores the results obtained by others who do not agree with him. In works practice there is constantly to be faced the simple fact that similar tensile and transverse tests are regularly obtained with silicons varying from about 1.00 per cent. to just over 3.00 per cent., and the writer witnessed the breaking of one test bar 2 in. by 1 in., with 3 ft. centres, which gave 32 cwts. transverse and 0.80 in. deflection, and which contained :—Silicon, 3.18 per cent.; sulphur, 0.06 per cent.; phosphorus, 1.20 per cent.; manganese, 0.90 per cent. This might be considered an exceptional deflection, but at the same works the daily average was 0.60 in., with a similar silicon content. Before both the West of Scotland Iron and Steel Institute and the Staffordshire Iron and Steel Institute I have given results of tests which were the same with silicon, 1.15 per cent. and 2.67 per cent., which confirm my everyday works experience that variations of silicon do not necessarily mean variations in strength. This is further shown in my Paper before this Institute in October, 1909, where additions of silicon in one case rather raised the tensile test results, whilst in a duplicate set of tests they lowered it, and in the transverse tests in Table III. of that Paper, the addition of silicon made no material difference in the one case, whilst in the other case the test results were lower. In a Paper given by me before this Institute in May, 1906, it was shown that the addition of silicon appeared to raise both the tensile and transverse tests. I obtained 48.9 cwts.—the highest test of that research—with silicon 0.91 per cent., using a similar material as the base of my investigations, viz., American washed iron. On this basis our results should have agreed more closely. Under certain conditions it may be quite true that additions of silicon will reduce the strength of cast iron; but I have never been able to prove that variations of silicon *per se* have any material influence on tests in foundry practice. It is not denied that silicon reduces the hardness of cast iron; this was clearly confirmed by showing that the additions of only 0.66 per cent. silicon reduced the depth of the chill from $\frac{3}{4}$ in. to 1/16 in., and made the fracture of the iron greyer. It would, however, be interesting to have Mr. Coe's opinion as to whether the influence of silicon in converting carbon to graphite is expressed as a chemical equation, or whether he considers it primarily a matter of temperature.

With regard to manganese, Mr. Coe refers to Hague and Turner's results of the softening effect—otherwise reduction of combined carbon—by the addition of 0.50 per cent. manganese. Unfortunately, there is given no complete analysis and fracture of the iron before the addition of manganese, and the manganese in the iron after the addition of 0.50 per cent. is also not given. It is therefore impossible to draw any conclusions as to the reason of the addition of manganese apparently softening iron. The cause may be in temperature, for it is well-known that 40 to 50 per cent. of the manganese oxidises when added to molten metal, and hence produces heat units. Some years ago a statement was made that manganese turned white iron grey, but on enquiry it was found that manganese was melted in a crucible with a certain iron and allowed to cool down in the crucible, which was left in the furnace until cold; thus by slow cooling the iron became grey—not because of the presence of manganese, but in spite of it. With regard to the effect of manganese on the strength of the iron, Mr. Coe's conclusions again do not agree with the results given in my Paper of May, 1906, although the base for our experiments was the same. Mine do confirm Dr. J. E. Stead's, and are also confirmed by the everyday works experience that when the manganese is much over 1.00 per cent. there is a decided weakening of the iron. It appears clear that the increased strength imparted to Mr. Coe's tests with low silicon and high manganese is due to some physical influence or chilling action on the test bars—the rapid cooling being, of course, influenced by the presence of manganese, and I am glad to note that Mr. Coe makes a statement which has frequently been voiced by me in public, but denied by chemists in discussion, viz., "the strength is more influenced by the change in fracture." He refers also to the influence on the structure of the fineness of the graphite, a subject which I have mentioned on several occasions before this and other Institutes. My later experience confirms my former statements that the change in structure has more to do with the tests of cast iron than analyses, and the influence of change of structure is a physical one, more than due to chemical composition.

With Mr. Coe's summary with regard to sulphur, I am in agreement. The natural outcome of his conclusions, however, is to ask what need, then, is there for chemical specifications of a standard sulphur of 0.05 per cent. maximum, with penalties if this be exceeded, such as proposed to the International Association for the Testing of Materials in 1909? Further, it is pleasing to see his statement with regard to iron containing phosphorus 1.00 per cent. as being useful; and whilst in the foundry high-phosphorus irons can, and do, regularly give good mechanical tests, it is not possible to agree with him that the addition of phosphorus *per se* increases tests; such statements to a foundryman are misleading, and the results I quoted in May, 1906, show that the transverse test decreases with the addition of phosphorus *per se*, as does also the deflection, suggesting a more brittle iron. Again these results were from the same base as used by Mr. Coe, and the first temperatures in each test were, as a matter of coincidence, identical, viz., 1,258 deg.; hence this statement that the addition of about 1.00 per cent. phosphorus appears to strengthen cast iron can only apply to his own results. They do not confirm my own tests either in research or works, and it would be dangerous to apply his statement as a principle to works practice. Mr. Coe further states that the addition of phosphorus up to 1.00 per cent. slightly diminishes the percentage of combined carbon. This is clearly indicated in my Paper of May, 1906, in which it is shown that the addition of phosphorus lowers the combined carbon (the depth of chill), and decreases the mottle at the back of the chill, thus producing greyer iron. In the Paper just mentioned, attention was also drawn to the softening effect of phosphorus, and this was commented upon by Dr. Stead in the discussion. It might now be suggested that the hardening effect of higher phosphorus *per se* in increasing the combined carbon is due to the reduction in the percentage of total carbon, which is considerable with the higher phosphorus, and even a contributory cause might be the method in which the alloy containing phosphorus was added to the metal. This reduction of the total carbon *per se* would materially increase the percentage of combined carbon on cooling, independent of phosphorus, and if too much alloy containing phosphorus were added to the metal when melted in the crucible, the result might be what is known as a "chilling," thus increasing the combined carbon. Mr. Coe will remember that in discussing both his and Hague and Turner's Papers ("Journal of I. & S. Inst.," 1910, II.), I pointed out that their conclusions

ignored the variations in total carbon, and the results were more likely to be due to the variations of carbon contents. Total carbon *per se* must not be ignored, and I have shown in various Papers that grey iron (*i.e.*, iron containing low combined carbon and high graphite) can be produced by increasing the total carbon, even in the absence of silicon, etc. Only in January last, in discussing a certain Paper, Professor Turner discredited my work, inferring that my conclusions were due to lack of practical experience. As the present Paper is given by one of his staff, it is perhaps a fitting opportunity to say that my statements, such as made in this discussion, are the outcome of personal practical works experience, as have been all the statements made in my Papers. It is probably a combination of technical and practical training which enables me to view the phenomena occurring in pig and cast iron in different perspective from those who have had no practical training; and it is possible that I may not always have been quite understood by the chemist because I have endeavoured to put things in such a way that the practical man would understand. In conclusion, Mr. Coe's pyrometric results are of very great interest, particularly in view of the curves presented by me before this Institute in October, 1911; and it would be interesting to have Mr. Coe's conclusions as to the cause of the lowering of the first arrest and the virtual disappearance of the arrest at which graphite is understood to separate out.

Making Flange Cylinders With Internal and External Branches in Loam.

By Sidney G. Smith.

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The following procedure, whether usual or unusual, in making cylinders with internal and external branches should be interesting. In former articles the author has described the methods adopted in cylinder making, and these will not be repeated in the present article; the detailed description given now will only refer to the method of moulding the double branches. Apart from this, the method for an external flanged cylinder is the same as before given in other articles. For clearness, care has been taken to give much detail, in order that the method of working may not only be understood by those engaged upon loam work, but also by those who are not directly employed upon such work.

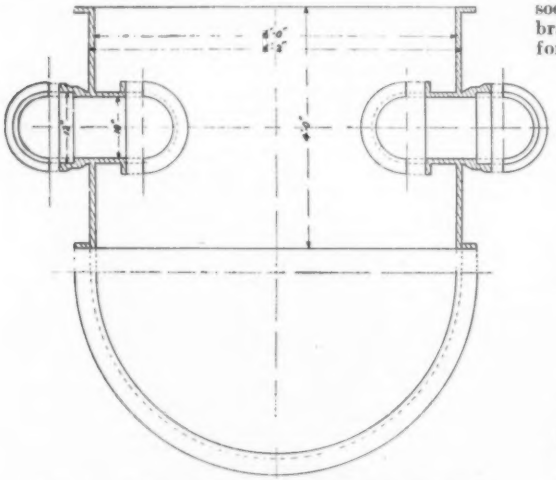


FIG. 1.—CASTING WITH INTERNAL AND EXTERNAL BRANCHES.

Fig. 1 is a sketch of the casting required; Fig. 2 is a section of the complete mould and tackle before being rammed up outside with rings; Fig. 3 is a section of the mould completed before the removal of the striking board; and Fig. 4 is a section of the completed core before being lifted away from its bracket and step and the removal of the core striking board. Fig. 5 shows plate A (Fig. 3) to carry the external branch boxes; Fig. 6 shows plate B (Fig. 4) to carry internal branch boxes; Fig. 7 shows the cake plate C (Fig. 4) and striking board, which covers and closes in the flange of the internal branch; Fig 8 shows the internal branch box D (Fig. 4); and Fig. 9 is the back view of the internal branch box (Figs. 7 and 8, when cottered together). Fig. 10 shows in section the cake plate E with striking board set, which covers and closes in the socket of the external branch; Fig. 11 shows the external socket branch rammed in the box; Fig. 12 the socket branch pattern drawn and the mould finished ready for drying; Fig. 13 the internal flange branch

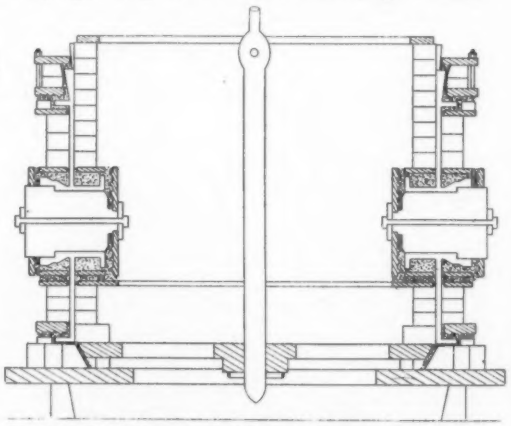


FIG. 2.—SECTION OF MOULD COMPLETE.

rammed in the box; and Fig. 14 the branch pattern drawn, ready for drying.

The procedure with the branches is similar to that for branch pipes vertically cast in loam, but the possibility of error in the present case is great, on account of the two branches being in direct line; and when it is remembered that the two external branches are bricked in the mould and the two internal branches are bricked in the core, and that one core passes through the internal and external branches, very accurate measurements must be ob-

served, as the least deviation of either branch will throw the thickness of the branches out of truth.

Each branch is rammed separately in a box with milled sand or ground loam par dried. When the branches are finished off and black-washed they are partly, or wholly, dried in order that they may stand handling (see Figs. 11, 12, 13, and 14).

When proceeding to do this, the cake plates (C and E, Figs. 7 and 10) are swept up in loam and

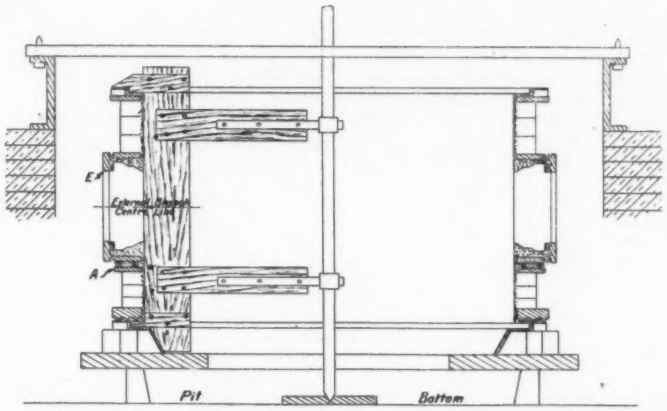


FIG. 3.—SECTION OF MOULD COMPLETE BEFORE REMOVAL OF STRIKING BOARD.

dried. The flange branch and socket branch patterns are laid on, the prints of which should fit that formed by the striking board; and the box being put on, is rammed, in the case of the flange branch. When rammed the

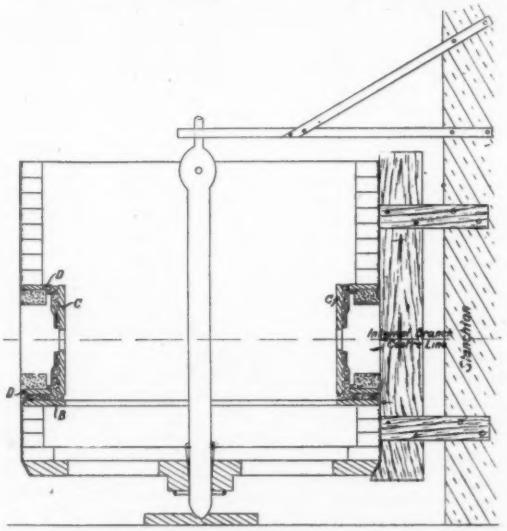


FIG. 4.—SECTION OF COMPLETE CORE.

pattern is drawn, the box and cake plate turned over, the cake plate lifted off, the flange pattern drawn, the cake plate replaced, cottered and again turned over. With the socket branch, after being rammed, the box and cake plate are turned over,

the socket pattern drawn, and the cake-plate replaced and cottered, and box turned over (see Figs. 11, 12, 13 and 14), and in each case dried or par dried.

Referring now to Fig. 3, the brickwork is carried up to plate A (Fig. 5), which carries the external branch boxes, a chalk mark on the striking board indicating its position, which is ascertained by the moulder measuring half of the square of the branch

box from the branch centre line, and making a little allowance for packing. When the plate is bedded in the loam the branches and boxes are set to the centre line on the mould striking board, which has previously been determined by the pattern-maker. The accurate setting of the branch is done as described in a former article, by inserting in the branch what may be called a double set-square,

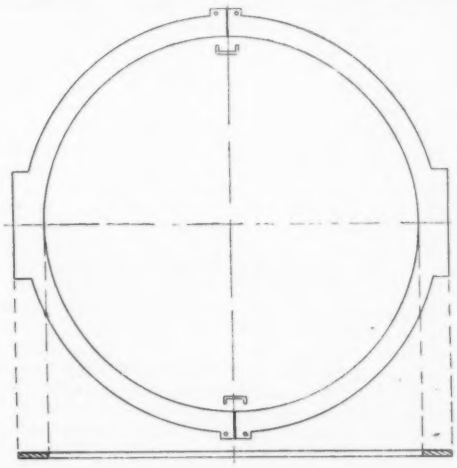


FIG. 5.—PLATE A (FIG. 3).

in the form of a wood cross (see Fig. 15, which shows the front view of branch box) which exactly fits the branch, the horizontal web of the cross being shaped to the external radius of the cylinder. The cross rests against the cake plate at the back of

the flange, and determines the length of the branch. When the branch is accurately set by means of iron packing, the striking board centre line should follow the radial web of the cross square, and the vertical web of the square should directly align with the striking board. When the lines and cross square are correct the setting of a branch occupies only a few minutes. These are checked over by the pattern-

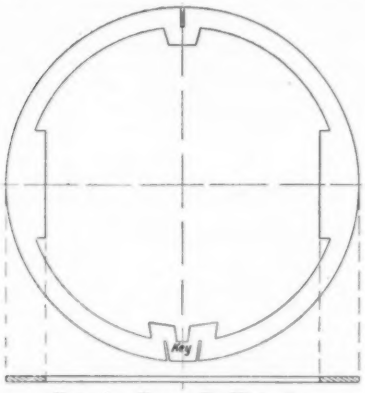


FIG. 6.—PLATE B (FIG. 4).

maker. It is obvious that for accurate working in setting branches the striking board must not be warped or twisted. When both external branches are set bricking is proceeded with as usual.

Referring now to Fig. 4, the setting of the branches is done on similar lines, but with the internal branches the curve of circumference is reversed, as will be noticed by the internal and external branch boxes, necessitating cross squares to suit. The difference in this case is that the core revolves.

FIG. 16.—STRAIGHT-EDGE FOR SETTING BRANCHES.

To set the branches in direct opposition, are used straight-edges recessed for the core spindle, in the case of the internal branches (see Fig. 16) and mould spindle (see Fig. 17). The same straight-

FIG. 17.—STRAIGHT-EDGE FOR SETTING BRANCHES.

edges are used as size sticks for setting the mould and core-striking boards when commencing the job.

Fig. 18 shows how the branch core is fixed and held. The figure shows a section of the cylinder and branches when the mould is put together.

Before putting the branch core into its place, the socket-branch cake plate E is taken off. The core,

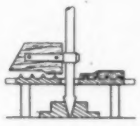


FIG. 7.—CAKE PLATE C (FIG. 4) AND STRIKING BOARD.

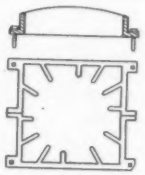


FIG. 8.—INTERNAL BRANCH BOX D (FIG. 4).

which may be made in either sand or loam, is then passed through, the end of the core having been tapered to fit the print or shoulder of the flange-

FIG. 9.—BACK VIEW OF C AND D COTTERED TOGETHER.

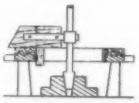


FIG. 10.—CAKE PLATE E WITH STRIKING BOARD SET.

branch cake plate (C) print and seat formed by the striking board (see Figs. 7 and 14); this centres the core at that end, and the bolt is then passed through a washer plate and core from the socket

FIG. 11.—EXTERNAL SOCKET BRANCH IN BOX.

FIG. 12.—SOCKET BRANCH MOULD.

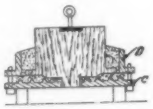


FIG. 13.—INTERNAL FLANGE BRANCH IN BOX.

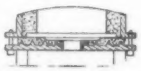


FIG. 14.—INTERNAL BRANCH MOULD.

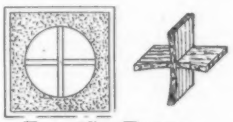


FIG. 15.—FRONT VIEW OF BRANCH BOX.

end; another washer plate is passed over the threaded end of the bolt; when through at the flange end the nut is screwed tight, and the core centred from the socket end. After this the cake plate E is replaced and cottered. The branch core is then secure, as it is pulled up from the socket end of the

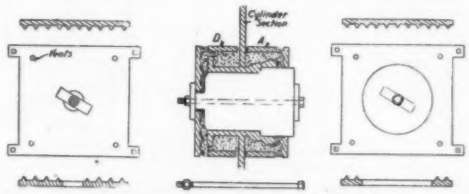


FIG. 18.—SHOWING HOW BRANCH CORE IS FIXED.

core to the seat at the flange end, the washer plate at that end overlapping the hole in the plate C, gripping the core as the nut is tightened.

When easing the main body core for contraction after the pouring, of course, the plate A (Figs. 5 and 3) which carries the internal branches is broken and the key-piece removed.

What a Patternmaker Sees in the Foundry.*

By William Mathews.

The function of the pattern-maker is, on the one hand, to interpret in practical fashion the ideas of the designer or draughtsman to the founder or moulder, whilst on the other hand he ought to interpret to the drawing office the peculiar difficulties of the founder and moulder occasioned by faulty design or extravagant refinements. It is indispensable that he should be able to read readily and clearly any drawing put before him, and to point out in intelligent language any inconsistences or discrepancies.

One side of a pattern-maker's training consists in what he sees in the foundry, and this continues from his apprenticeship until the last day of his active connection with the trade. It is impossible to over-estimate the importance of this part of his training, because on it depends very largely his success as a practical pattern-maker. He may at the outset be somewhat puzzled by the different methods adopted in different foundries, and especially by the pronounced differences in the practice of different districts. But it may be laid down as a general principle that the pattern-maker has to conform to the needs and methods of the shop or shops where he may from time to time be located.

He may, of course, and should suggest alterations in the methods of doing certain jobs, since no shop or district has a monopoly of the best practice in every particular; but as a general principle it may be stated that the system of moulding in any district is, broadly speaking, that which has been evolved by years of experience as the best fitted for that district, and as a consequence the pattern-maker has to accommodate his views on patterns to the established practice. The writer proposes here to record some of his impressions based on actual experience of the different methods adopted in connection with large castings for marine engines, both reciprocating and turbine, first of all in the Clyde district, and next those in vogue on the Tyne.

Clyde and Tyne Methods Prepared.

Cylinders, condensers, and sometimes columns for reciprocating jobs, as well as casings for turbine engines, are in most foundries in the Clyde Valley made in loam, a class of moulding in which that district excels. Patterns required for this practice are of open-frame-work construction, leaving to a considerable extent their own cores—that is, wood framing is made drawing thicknesses, and as far as practicable cores are made inside the pattern. Moulds are built on a strong bottom plate, and the walls of the mould or "cope," as it is called, are reinforced by light-section building or cope rings.

The mould is covered with a large, strong plate similar in area to the bottom plate, and both plates are furnished with strong lugs at intervals right round the edges. Care is taken that these lugs on the top and bottom plates coincide, and are enagaged by strong binding bars, to withstand the vertical pressure exerted during the casting process. In order to counteract casting pressures in lateral directions the mould is lifted into a pit in the foundry floor, and sand is rammed hard and tight between the outside of the mould and the inside of the pit. This ramming is done by unskilled labour.

This method has some advantages and disadvantages, which may be briefly enumerated:—

Advantages.—Patterns can be put together somewhat rapidly, and with a considerable saving in timber costs. Close approximation to drawing thicknesses may be attained by the practice of making cores inside the pattern.

Disadvantages.—Time saved in the pattern-shop is discounted by longer time taken to complete the job in the foundry, because it is obvious that a method which demands the building up of cores inside the pattern before the actual moulding commences, will take more time than the alternative method of making moulds and cores independently and concurrently. The patterns being of a somewhat flimsy construction, will not stand much wear and tear incidental to foundry routine, and require more screwing together for repeat orders than is necessary in the case of solid patterns.

To sum up, the foregoing procedure in regard to patterns and moulds has strong recommendations in its favour in dealing with special jobs which may not be repeated on exactly similar lines.

In the Tyne district, as is very well known, dry-sand moulding is the predominant feature in foundry practice. It is true loam moulding is not unknown, but one can easily understand the reluctance to adopt more extensively this method when one sees the large amount of heavy tackle required. Loam jobs in this district are cast naked; that is to say, they are cast on floor level, and consequently no sand ramming around the loam building is practicable.

Some explanation is here necessary regarding the respective methods and modes of loam moulding on Clyde and Tyne. Both methods require heavy top and bottom plates; but whereas the building rings on the Clyde are of light section and quite flat, and can be made on the bed at the rate of from four to six per day, the Tyne practice demands the same rings to be heavy section, and having long stiff prods or "dabbers" cast on, with the result that only one ring can be cast per day on the same amount of bed room as that occupied by from four to six under the Clyde system. The making of tackle on the Tyne for loam jobs is therefore a serious matter, and accounts very largely for the fact that loam moulding in that district has not been practised more frequently.

Dry-sand moulding for the class of castings under discussion requires a solid pattern, made up of heavy internal framing covered over with lagging, and all cores made separately by means of boxes or strickles. The heavy internal framing referred to is for the most part made of yellow pine, which is doubtless the most suitable wood for such purposes, inasmuch as it stands very well without twisting. When numerous repeat orders are anticipated, yellow pine should be employed throughout, but where such repeats are not likely then it is permissable to make the framing of white pine, thus reducing the cost of timber very materially. White pine however is not so reliable as yellow pine, and care must be taken to have the framing stayed in such a manner to prevent the well-known tendency of this material to warp. The lagging used should always be made of yellow pine, and

* Abstract of Paper presented before the British Foundrymen's Association, Newcastle-on-Tyne Branch, April 26, 1912.

care taken to have all joints kept ¼ in. open, thus allowing for the wood swelling in contact with the damp sand in the foundry.

The advantages of this style of pattern-making may be enumerated as follows:—(1) Rapid delivery of castings. (2) The patterns for this style of moulding have a long life, and for repetition work they very soon recoup the engineering employer for their high initial cost. Conversely this high initial cost, especially in material, is a discouraging factor in the case of special jobs.

Patterns for Engine Details.

It is now proposed to discuss briefly the patterns for engine details and pipe-line work. The pattern-maker here must exercise a wise discretion, since there is no class of castings where money can be thrown away more readily than in making small castings from "shoddy" patterns. In this connection it may be stated that moulders have at times a legitimate cause for grumbling at the sorry apologies for patterns they sometimes receive, and it is really surprising that they are able to turn out the fairly decent jobs they do when handicapped in this respect.

For small dry-sand jobs where it is probable there will be repeats wanted, good patterns ought to be insisted upon, whilst for green-sand moulding it is foolish policy to indulge in anything but the very best the pattern-maker can give. Green-sand moulds ought never to be mended or patched; the pattern should strip perfectly, leaving the mould intact.

Core Requisites for Detail Work.—The method of making cores, especially for branch pieces and valve chest and boxes, may here be dealt with. It is permissible to make cores by means of core frames and strickles where the quantities required are few, but for repetition work full core boxes should be provided. There ought to be in all foundries a proper relation between the capacity to make moulds and cores. It is very annoying when moulds are hung up waiting for cores, or when cores are ready too soon for the moulds, and as a consequence run the risk of becoming chipped or damaged during the period of waiting. The pattern-maker ought therefore to make adequate provision for handling the jobs in the foundry on something like concurrent lines.

With further reference to this question of core-making, it may be pertinent to emphasise the desirability of painting in on joint of patterns, a section of the casting. This practice helps materially in the accurate placing of cores in the moulds. As showing the importance of this may be cited as example, valve chest and boxes. In this class of goods it is sometimes imperative that careful attention should be bestowed on the direction of steam or water, which is usually controlled by internal divisions or walls of metal. There is nothing more aggravating than to find otherwise good castings spoiled by want of attention in this respect, owing to the moulder turning the core end for end. This may fit the core prints all right, but when the job is cast it is found to be useless because the internal arrangement is contrary to the design.

It may be argued here that the pattern-maker ought to see to it that it is impossible for the moulder to get wrong in this matter, by flattening core prints or by some device of that nature; but the writer is here arguing for a more enlightened attitude on the part of the foundry, and enters a plea for careful observation and intelligent appreciation of the purpose for which the article being made is intended, and deprecates very strongly the notion that patterns and core boxes should be made "fool-proof," a procedure which puts a premium on ignorance, fosters negligence, and is not calculated to develope the thinking powers of the men.

During the closing of important moulds of large size it is desirable that the pattern-maker should be in attendance, as sometimes a good deal of time and trouble can be saved by deciding promptly matters in regard to which the foundry people have doubts. An experience of this kind generally tends to make the pattern-maker more particular in his methods of making core requisites, inasmuch as the position of staples in core grates for lifting purposes, the connection of vents between one core and another, are points which probably he had not specially studied or even thought about at all.

One other remark on this topic may be permitted, and that is that during the operation of "closing" the workmen ought never to be harrassed. A large number of the preventible mishaps in the foundry are due to want of care in handling and securing cores, or want of attention to the making up of vents. It ought therefore to be remembered especially by engineers anxious for delivery of their castings, that whatever rushing may be expedient during the ramming of the moulds, at the closing of the job patience is the only virtue.

Filleting and Rounding of Corners.—It is desirable that the patternmaker should know something of the laws of crystallisation of metals, as such knowledge would teach him the importance of filleting and rounding of corners. It is sometimes regarded as unnecessary labour, and only a concession to sentiment to finish jobs in this way; but to those who have taken the trouble to study even in a casual manner the formation of crystals, there is no doubt whatever that nicely-rounded corners on castings are desirable for the purpose of eliminating planes of weakness in the castings, and incidentally achieving the distinction of turning out a good-looking job.

In small patterns filleting ought to be carried out on the patterns, but in larger work where cost precludes this being done, the moulder has to make good the deficiencies of the pattern in this respect.

The pattern-maker may assist by making small edge templates cut to the radii of the corners required, these to be used by the operator when finishing moulds or cores. Some moulders have the most grotesque ideas as to what is fitting in this respect. They have great faith in the efficacy of the "rubber" or "card" in taking corners off cores especially, and apparently think they have *carte blanche* to rub and scrub until they become weary of the game.

The writer has heard of some cases of what may be called "methods of barbarism" in the foundry, two of which may be recited, not because they are characteristic of the foundry generally, but as representing the loose ideas entertained by some moulders as to rubbing of cores and moulds. The first instance is that of two loam moulders who had some cylinder-covers and pistons of the ordinary box-section to make, the cores for which were divided up by radial ribs put in for stiffening purposes. The workmen concerned used their own judgment as to the number and thickness of these ribs. Needless to say the scantlings were grossly in excess of that specified. Practices of this kind can only be detected by close supervision on the foundry floor, because once the job is cast the parts in question are usually inaccessible to gauge or measurement.

The second case is that of the operative who was renowned for his vigorous use of the shovel in taking corners off large cores; he declared the implement named was the best suited for such purposes; of

course, corners taken off in this manner were of the most generous and ample character.

The worst feature of such mal-practices is not merely the superfluous metal for which the buyer of the casting has to pay at enhanced rates if he is not careful in checking the weights, but the restriction of areas in steam passages and the abnormal sections sometimes created which are apt to set up internal strains due to unequal cooling.

While on this topic it is only fair to say that sometimes moulders are put to great inconvenience when closing jobs through cores fitting badly owing to want of care on the part of the patternmaker, which necessitates at times the rubbing of cores to such an extent that the casting of the job has to be put back for possibly another day.

Cooling Strains.

Reference has been made to strains set up owing to unequal cooling, and the founder is justified in taking steps to prevent this, by thickening or bulbing up ribs which, as they appear on the pattern, are likely to set before the adjoining parts of the casting are quite at rest. Casting strains set up by unequal cooling sometimes make their presence manifest in the form of cracks in ribs, which are rarely detrimental in a vital sense to the casting, notwithstanding they are a "bugbear" to overseers and engineers who have no practical knowledge of foundry problems. It perhaps would be correct to say that the casting is better after such cracks have made their appearance than it was before, because in foundry parlance the casting has "eased" itself, and may be regarded as free from the internal strain which was the cause of the rib tearing. It is difficult, however, if not impossible to convince people who do not appreciate this of the correctness of the reasoning, and it is decidedly much better to take reasonable precautions against such things happening by using the means indicated above; and the pattern-maker would be well advised to take this matter into account, and anticipate the founder in this respect.

Shrinkage and Contraction.

In regard to contraction, the pattern-maker cannot rely on text books for such allowances, but must be guided solely by his own experience. Ordinary foundry grey iron requires 1-12 in. per foot, while for hard cast iron with a mottled fracture $\frac{1}{8}$ in. per foot is good practice. For brasses and bronzes $\frac{1}{8}$ in. in 9 in. should be allowed, and for very large castings $\frac{1}{8}$ in. per foot, plus $\frac{1}{8}$ in. in every 10 feet, has been found by experience to be sufficient. Steel castings require a contraction allowance of 3-16 in. per foot.

Sometimes jobs crop up in regard to which no contraction should be allowed in certain directions, for example large slide valves, which have large flat surfaces parallel to each other. Between such faces it is an invariable experience to find that the casting has strained, and on measurement is found to be in excess of given dimensions, the pattern therefore ought to be made less than drawing size between the face and back of valve, the amount of such deduction to be regulated by experience, because when very stiff moulding boxes are used the tendency of castings thus to swell is proportionally reduced.

Cores made in the Mould.

The pattern-maker is occasionally called upon to handle comparatively large jobs of very irregular shape, and at the same time it is desired that drawing thickness should be faithfully observed. The making of a core box, while not impossible, is certainly not advisable, and the usual way in such cases is to make the core in the mould in the following manner.

The pattern is rammed up and withdrawn, and the mould finished in the ordinary way; next a layer of clay or stiff loam the exact drawing thickness is laid over the whole surface; any facings, ribs, etc., required are prepared by the pattern-maker and located by him in mould; and the core is then proceeded with in the usual manner. For the most part cores thus made are made in loam. Cores made in this fashion follow the contour of the job with great exactness; the one strong objection to the procedure is the long process involved.

Chaplets.

First of all it may be laid down that chaplets should only be introduced into a mould when all other means of securing cores have been discussed and found impracticable. It is, of course, a mere counsel of perfection to advocate the abolition of chaplets, but to the pattern-maker who observes carefully, it must be apparent that sometimes moulders are very lavish with these commodities, and seem to use them without reason.

The objections to chaplets from the engineers point of view may be summarised as follows:—They break up to some extent the structure of the casting, because they never fuse and become incorporated into the job, and ought therefore to be regarded as foreign bodies inserted into the mass. They are apt to induce lines of weakness in the job, especially if care is not taken to have them staggered instead of having them arranged in orderly rows. They are also very often troublesome when the casting is under water test, because of the porosity of the metal in their immediate proximity, a porosity caused, perhaps, by the black or red oxides adhering to the chaplets, which oxides in combination with the molten metal give off gases.

The pattern-maker's part in the discussion comes in now by suggesting to the drawing office the desirability of opening out castings, to allow of cores being stayed or bolted to the mould.

It may be argued here that such openings would weaken the casting, but if such openings were put in with the consent of the draughtsmen, he would naturally take care to reinforce the job at these parts; and in any case it is better he should know and make provision for such contingencies, than have the casting riddled with small holes in all directions without his cognisance. For small work which has to stand high-pressure water tests such as boiler stop valves, the pattern-maker ought to furnish his patterns with adequate core prints, and also see that his cores are made all in one, and that the core prints engage the core in an efficient manner.

Assuming that the foregoing has been done, it then rests with the foundry to cast the job in such a position that the largest core print is at the top of the mould, into which the core is fixed and anchored, so that the straining action generated during the casting process has no effect in distorting or moving the core. If these precautions are taken, it is quite possible to cast such jobs without any chaplets whatever, and the result is a stronger casting likely to stand severe water tests without any of the vexatious troubles incident to leaky castings.

In conclusion, the writer would say that the pattern-maker's duty does not consist merely in receiving drawings and sending out patterns, but

that a great deal more than that is required of him if he is to keep his trade as the leading trade in the engineering world. He must keep his mind free from prejudice and bias, and be at all times prepared to change his methods in the light of new experience.

He ought to facilitate the work of the drawing office and foundry by tendering his advice on critical points. His attitude to the foundry should be that of helpful consideration, remembering that the problems in the foundry are many of them harassing to those in charge there, because of their apparent insolubility. He ought to have reasonable access to the drawing office, where he should have the opportunity of stating his opinion on the work, because as a rule comparatively few draughtsmen have any pattern-shop experience, and none at all of the foundry. If he proceeds on the lines indicated, he will probably find his advice solicited, and his views adopted. Finally, whatever rules the pattern-maker makes for his own guidance in the varied circumstances of his calling, he ought to administer them all in the spirit of common sense.

Discussion.

MR. CARMICHAEL, referring to chaplets, said it was the aim of the founder's life to get a casting without chaplets.

MR. EDWARD SMITH referred to Mr. Mathews' suggestion that the method of moulding on the North East Coast was superior to the Scotch method, and said one of the chief advantages of the former was that they could make the moulds so much quicker, the cores and the mould going together, and one was ready at the same time as the other for closing. The art of green-sand moulding was lost to a certain extent in the North of England, perhaps more due to the best men wanting to leave the green sand in order to get on to the dry sand.

MR. PAULIN said it was a pleasure to hear one who had such a grip of the relation between the making of the pattern and the using of it. One generally found the views expressed by the pattern-maker to be antagonistic to those of the foundryman. He had been much interested in the portion of the paper which referred to the use of chaplets. He certainly thought that chaplets were used carelessly. In jobs like a steam belt or a jacket he had frequently found the inside lining destroyed by a chaplet, and that could have been avoided quite well by leaving out the chaplet and piercing the outer skin, leaving a "stud" as it were of core to rest on the outer body of the mould. The correct thickness could then be got without the introduction of a chaplet, and the inside perfectly sound and free from any chance of bubbling in the neighbourhood of the chaplet, the stud hole being filled by plugging. Mr. Mathews' contention in favour of making the sections on the patterns was excellent, if only from the point of view that it would compel the moulder frequently to exercise a little more brains in his work. Regarding filleting by hand, such a fillet generally was a sort of flat at 45 degrees lying right across the corner; there was no idea of rounding the corner, and the object of reducing bad crystallisation was not attained at all.

MR. MCLACHLAN said he did not believe in chaplets, but they were unavoidable at times. He thought a little "give and take" between the foreman pattern-maker and the moulder or the foundryman would bring better results to all concerned.

THE CHAIRMAN said the cracking of ribs, in his opinion, was due sometimes to a disregard of the proportion of the ribs to the proportion of the rest of the casting, and sometimes to a feature which Mr. Mathews had not touched on, and that was the material of which the casting was made; and again many times it was due to the whole question of design. One would think that the draughtsman who designed the casting intended the ribs to be cracked. On the question of chaplets Mr. Mathews had rightly and properly laid considerable stress, and the example he took, that of a steam stop valve, was perhaps the most important example that he could have chosen, it being a casting subject to changes of temperature and changes of stress, the stresses in a great many cases being incalculable. One feature in the casting which it was highly important should be observed in view of that strain was that of unequal thicknesses due to movement of the cores. Any unequal thickness might stand a steady internal pressure, but if to that were added a cross twisting stress due to badly arranged steam pipes, it was a very questionable fact whether those stop valves would not be strained very nearly to breaking point. Consequently chaplets which might, and very probably did, form points of weakness in those castings should be avoided.

MR. MATHEWS, in reply, said he had seen a great many castings condemned by men who did not know anything about foundry practice at all, simply because of cracks which did not affect the casting. With regard to ribs, he thought that if the precaution was taken to make the ribs thick enough, that would probably prevent cracking. The pattern-maker was the proper intermediary between the founder and the drawing office; he ought to make himself that at least, by becoming acquainted with foundry practice. With regard to marking sections, if the moulder would take precautions to have the pattern alongside him he would see exactly how the core should be arranged, and would have no excuse for disregarding it. Mr. Edward Smith had referred to the North East Coast system being superior to the Clyde. It was, without doubt, better in some respects for repetition work, but for special jobs he thought the Clyde system was preferable. The reason alleged for the green-sand work being lost in the North was the unsuitability of the sand, but he was inclined to agree with Mr. Smith that it was to some extent due to the men wanting to get on to larger work.

The meeting ended with a vote of thanks to Mr. Mathews.

The Junior Institution of Engineers.

On the 29th anniversary of the foundation of the Junior Institution of Engineers, Monday, June 30, at the Institution of Electrical Engineers, Victoria Embankment, the second Gustave Canet lecture will be delivered by Dr. Dugald Clerk F.R.S., who has chosen as his subject "The Working Fluid of Internal Combustion Engines." The late M. Gustave Canet (Past President of the Institution of Civil Engineers of France) was president of the Junior Institution of Engineers in 1907-8, his death occurring at the close of his term of office. In accordance with a wish he had expressed, Madame Canet MM. Paul and Albert Canet, and their families, presented a sum of money to the Institution to form a Gold Medal Fund in commemoration of his presidency. The gold medal is awarded quadrennially to an officer or member of the Institution invited by the Council to deliver a lecture on a subject of importance to the engineering and scientific world. The first award was made in 1909, the lecture on "The Engineering of Ordnance" being delivered by Lieut. (now Sir) A. Trevor Dawson, R.N., M.Inst.C.E., M.I.Mech.E. (president of the Institution in 1912-13), who will preside on the occasion of Dr. Dugald Clerk's lecture.

Iron and Steel Under the Microscope.

Before the Halifax and District Branch of the British Foundrymen's Association on Saturday, March 15, Mr. E. W. Smith, B.A., B.Sc., gave a lecture on "The Structure of Iron and Steel as seen under the Microscope."

Mr. Smith, at the commencement, said the lecture would be essentially an introduction to the subject, and therefore was quite suitable even to those who had no previous knowledge of this branch of the metallurgy of iron and steel.

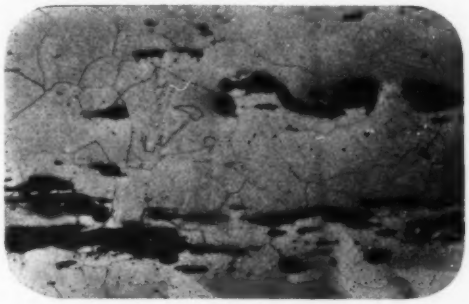


Fig. 1.—Slag in Wrought Iron; Ferrite Crystal Outlines are seen in Light Areas.

To begin with he defined the following metallographic constituents of iron and steel:—

Ferrite (Fe); carbon (C), in the form of graphite; iron carbide or cementite (Fe_3C); iron sulphide (FeS); manganese sulphide (MnS); iron phosphide (Fe_3P); and pearlite (21 Fe to Fe_3C). As illustrating a eutectic he referred to the familiar example of the ice-salt eutectic, which consists of 23.6 per cent. of salt to 76.4 per cent. of ice, and melts at −23 deg. C.

The lecturer next explained how to prepare a sample of iron or steel from the workshop for microscopical

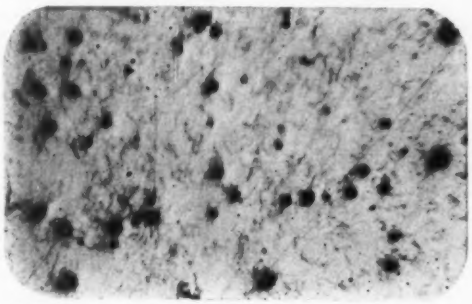


Fig. 2.—Much Crystallised Cementite; Black Patches are Graphite.

examination. He illustrated the passage from emery paper No. 1 over No. 0, No. 00 and No. 000, to No. 0000, at each stage the sample being rubbed at right angles to the previous direction of rubbing. The polishing, especially with cast iron or steel, was easily completed on a wet cloth, using jeweller's rouge as a polishing agent. The specimen (a hard steel) at this stage was shown to illustrate that as a rule no structure of the metal is developed by simple polishing, the surface merely showing impurities like slag inclusions. After polishing, the structure was developed by a light picric acid etching (5 per cent. solution of picric acid in alcohol). Two further illustrations showed a sample of wrought iron containing slag, the first with the slag in lines as caused by the working of the metal, and the second with the section at right-angles to the previous one, thus showing the slag in spots. The ferrite crystals in the first are also shown in Fig. 1, the edges being attacked by the etching medium.

With a little practice the amount of combined carbon present could be closely estimated from the amount of pearlite showing, 0.89 per cent. of carbon being the amount present when the whole groundwork was pearlite. A further illustration (Fig. 2) showed a chilled cast iron with much crystallised cementite, which accounted for the hardness of such metal; the half-tone areas are pearlite and the black patches graphite, as the chilling had not been sufficiently rapid to keep the whole of the carbon in the combined condition. Thus the difference in the appearance in passing from a wrought iron with only traces of carbon, through mild, medium and hard steels up to a chilled cast iron with 1.7 per cent. combined carbon, was explained.

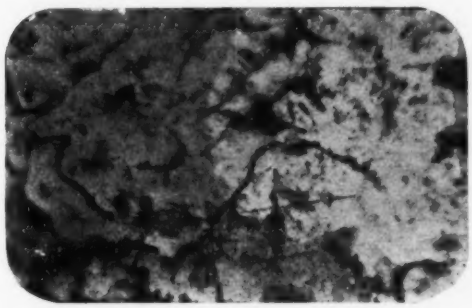


Fig. 3.—Large Flaky Graphite in Cast Iron.

Dealing now more particularly with cast iron, the lecturer explained how the structure was sometimes developed by prolonged polishing—"polishing in relief," as it was called; the softer parts were rubbed away, the harder parts standing up in relief. Thus graphite, as well as slag, was shown in an iron by mere polishing, so that before etching, a cast iron specimen showed the slag and graphite, the condition of the latter, whether small or well distributed, or in large irregular flakes, giving some indication as to the strength of the iron. Fig. 3 shows large flaky graphite and Fig. 4 the smaller graphite of a stronger iron. Fig. 5 shows the polishing in relief of a chilled iron, where an appearance of cementite and pearlite is shown similar to what would be obtained by etching. Fig. 6 is the same as Fig. 4, after etching, there now appearing in addition to the dark patches of graphite the half-tone areas of pearlite. Illustrating next irons deeply etched with dilute nitric acid, when the whole ground was darkened with the exception of the part containing the iron phosphide, the lecturer remarked that the phosphide in one example was in the form of a decided network, which form Messrs. Hailstone and Cook considered, other things being equal, to produce great strength in the iron

Discussion.

Mr. Campbell, in opening the discussion, said he thought that in micrography, which was quite a modern departure in metallurgy, a very wide field had been opened. Dr. Sorby was the pioneer of the science. Many questions had yet to be answered before definite conclusions about metals could be got. The longer he lived the more he was amazed at the freaks which cast iron played from time to time.

Mr. T. Dean asked the lecturer if he could take a micrograph of a sample of cast iron which he had brought with him.

Mr. Campbell asked if there was any theory held at the present time, other than the network theory advanced by Messrs. Hailstone and Cook, as to how one could form some idea of the different strengths of irons or steels of practically the same chemical composition. He was often puzzled to account for two specimens with the same composition, one giving good results and the other indifferent or poor results.

Mr. W. E. Linfoot said some of the queer results obtained from specimens of the same composition, were due to the different rates of cooling.

Mr. R. Pickles wanted to know how it was that the network structure could be different in two test bars cast in the same box and attached to the same casting. He had taken two test bars during that week, cast under the conditions mentioned; one had

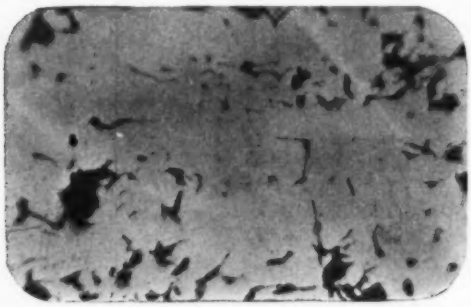


Fig. 4.—Smaller Graphite in Cast Iron; a Stronger Iron.

broken at 22 cwts. transverse and the other at 32½ cwts. transverse stress. Surely results like those made the study of the question intensely interesting.

Mr. T. Dean also mentioned two test bars which were taken the same morning, one breaking at 30 cwts. while one was still sound with 2 tons on it.

Mr. Love said he had come to the conclusion that casting two or more test bars in the same box was wrong. He had tried casting up to five and six test bars on the same casting, and had obtained all manner of results, except uniform results. He said he had been forced to the conclusion that something got into some bars and had a weakening influence.

Mr. Berry said he thought a microscope should be part of the equipment of a foundry. A better idea as to the cause of the unequal results of tests could be formed by examining the fractures.

Mr. W. E. Linfoot said he thought part of the variation in results of tests was accounted for by a jerk during the tests.

Mr. A. Edwards asked why the picric acid reagent worked on the boundary and not in the centre?

A Visitor said he thought the trouble arising out of tests was due to unequal loading, or partly from that cause. A sudden load would give double the pressure, because when applied quickly the effect became dynamic.

Mr. Whiteley said he thought no definite solution to the problem could be found. The lecture and discussion indicated that the scientific side of foundry work was the side along which progress would have to be made.

Mr. Smith, in his reply, acceded to Mr. Dean's request to take a micrograph of the sample of cast iron, and promised it during the week. In respect

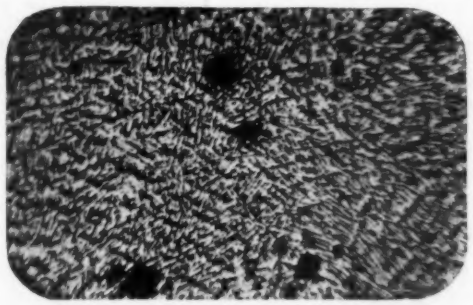


Fig. 5.—Chilled Iron Polished in Relief.

to the remainder of the questions, he said that if the test bars cooled at different rates, they might not have the same combined carbon, and therefore the composition would be altered. If he could answer Mr. Pickles' question, there would be no need for Messrs. Hailstone and Cook to continue their research on the strength and structure of iron. He should be glad to have two samples of his test bars to see if the network structure was the same, or to see if he could find any flaws showing weakness. A general answer would reply to many of the questions. A fracture might be examined with the naked eye and no flaw be seen in it, but if put under the microscope lines of weakness which were invisible to the naked eye would be found. With regard to different bars of the same composition giving different tests, it should also be remembered that the

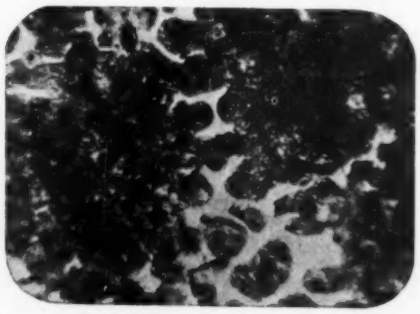


Fig. 6.—Same as Fig. 4, after Etching.

condition of the graphite would have an influence, strong irons having the graphite small and well distributed, and weak specimens having large graphite flakes. The reason why picric acid reagent acted on the outer boundary of the ferrite crystals and not on the inside was because any impurities would be between the crystal grains and these were more readily affected than the uniform pure irons.

A vote of thanks to Mr. Smith concluded the meeting.

British Foundrymen's Association.

Annual Meeting of Lancashire Branch.

The annual meeting of the members of the Lancashire Branch was held on Saturday, May 4, at Manchester, Mr. F. Penlington presiding.

The election of the officers and committee for the next twelve months resulted as follows:—President, Mr. Joseph Simkiss; Vice-Presidents, Messrs. Markland, Oliver Stubbs, and H. Sherburn; Secretary, Mr. A. Harrison; Auditors, Messrs. Grandedge and Hargreaves; Committee, Messrs. Andrew, Kenyon, Hilton, Key, Sutcliffe, Hogg, and Penlington.

Mr. Harrison (Branch-Secretary), in making his report for the year, said it had been a most successful one. There had been an increase of three members, 13 associate members, and 16 associates, raising the total numbers to 30 members, 94 associate members and 36 associates. Including a balance brought forward from the previous year, the income had been £20 2s. 9½d., and the expenditure £14 3s. 4½d., leaving a balance in hand of £5 19s. 5d.

Mr. W. H. Sherburn moved that the report be accepted, and that thanks be given to the officers and committee for their services during the 12 months.

The motion was carried unanimously.

The Chairman, in acknowledging it, expressed a hope that the members would loyally and cordially support Mr. Simkiss, so that at the end of his term of office he might be able to look back with satisfaction upon the results of his work.

FRACTURE OR ANALYSIS?

The meeting then proceeded to discuss the question of "Grading by Analysis of Fracture," which was introduced by Mr. Andrew

Mr. Andrew introduced a discussion on the subject of grading by analysis or fracture. He said the relative merits of these methods had been discussed at various times. The man who was accustomed to select irons by fracture, having no experience or faith in chemical analysis, relied on physical characteristics, such as the appearance of the fracture and of the upper surface of the pig, the ease with which the pig was broken and the touch on the fractured surface. The value of this method depended entirely on the experience of the person who used it; his knowledge, however great, could not be readily transmitted to another person, nor could it be truly described as scientific. When dealing with strange materials whose origin he did not know, he was liable to judge their properties incorrectly. The principal argument against chemical analysis was that pig-irons yielding practically the same analyses were found to vary considerably when subjected to physical tests. That might be due to incomplete analysis of contents, a difference in the state of contents, or a difference in the conditions under which the test pieces were produced. The argument, therefore, was not sufficient to condemn analysis. As a set-off, instances might be given where two test bars, cast in the same box, the ingates being supplied with the same down runner, gave different results under test. One need not go beyond a single test bar to find variations which became more pronounced the lower the temperature, below normal, at which the castings were poured. Ordinary analysis might indicate no difference in two irons, whereas the microscope would reveal large flakes of graphite in one case and fine graphite in the other. Where a bar was cast on a large casting, the test result from this bar could not be considered representative; it would differ from the result obtained from a bar cut from the casting itself. This brought forward the question of the state of contents of the metal, which was undoubtedly influenced by the rate of cooling. The state of the carbon was held to be largely responsible for variation in results, and in the same metal the carbon could be obtained as all combined carbon, fine graphite, or coarse graphite, according to the rate of cooling. If this was the cause of the difference in size of graphite, it would seem advisable to bring about, in some cases, a rate of cooling which would result in a finely divided graphite and the resultant higher tests which were attributed to its presence.

Use had been made of chills to increase the rate of cooling to prevent spongy places which leaked under pressure tests, and it was just as reasonable to expect good results from other tests by judiciously increasing the rate of cooling.

To be really comparative the production of test pieces must be carried out under standard conditions. These were likely to be disregarded and treated as not being necessary in practice; but he contended that if the results of tests not carried out under standard conditions were placed before foundrymen there was danger in accepting them, as they could not be considered reliable There would be liability to misapprehension just as in deciding the cause of bad castings in the foundry an incorrect opinion was often formed and the wrong remedy applied with bad effects. He might mention a case where two metals of practically similar analysis were subjected to tests for about 60 consecutive days and gave widely different results.* One was remarkable for high results; the other gave results considerably lower, in fact its highest was much less than the lowest of the No. 1. In the analyses of the two there was a slight difference only. Unfortunately the constituent brands of the mixtures were not given, but it was stated that three brands were used in each, and there was only one pig-iron different. The apparent reason for the difference in the results was shown by the microscope. In the one case the carbon was finely divided graphite, in the other a larger flaky graphite. Apparently, therefore, one mixture had a different rate of cooling to the other. If analysis would not explain the reason for the difference conditions must, and it was highly probable that the temperature of production of one or more of the constituent brands was much higher than that of the others, producing a state of contents which would perhaps remain unaltered, even under several ordinary cupola remeltings, unless the two mixtures were separately subjected to a temperature approximating to that of the hottest blast furnace when probably, if the tests were again applied, the same results would be obtained in each case.

In conclusion, he expressed the opinion that the chemist could not, and would not, accept any other basis than this:—

That the same elements, in the same proportions and under the same conditions, would produce the same

* From Proceedings of B.F. A., 1908 and 1909. F. J. Cook and G Hailstone on the Effect of Structure upon Physical Properties of Cast Iron.

compounds, complex or otherwise, which would also possess the same properties.

Discussion.

MR. CORDINGLEY said that it astonished a practical man to find that two irons apparently different when subject to tests might yield very similar analytical results. Two brands from a certain district might produce a mottle, and two brands from another district also produce a mottle; but on testing, there could be a difference of four or five tons between them, while they still appeared very much the same. The analyst sometimes went astray, but judgment by fracture was also misleading, and for his part he preferred to be guided by analysis. He should like someone to give information on what it was that changed the strength of the material when its appearance was the same.

MR. WOLSTENHOLME considered that the best method of testing iron was by the microscope; with its aid the tensile strength of the iron, its openness or closeness, machining properties—everything, in fact, which was required, except its fluidity—could best be determined. Little or nothing of what happened to the iron when it was in the furnace was known; variations in the conditions there affected it so much that the founder could not be sure what he was going to get. He had known a really good and tried mixture to produce bad iron, and, on the other hand, he himself had tried the lowest class of scrap and got really decent iron. Analysis alone was not sufficient.

MR. CORDINGLEY remarked that it would be difficult to judge the tensile strength by the microscope.

MR. WOLSTENHOLME said two irons which looked alike might be very different when viewed through a microscope. Some time ago he had reason to suspect certain irons. He took them to a man who had had 30 years' experience in grading, and he pronounced them to be alike; but when cast and tested they were found to be different. He then took five chips off each, examined them under the microscope, and found there was a difference in the structure. In one the flakes of graphite were a little longer and more prism-shaped than in the other. It was not perceptible to the naked eye, but it made a difference in the tensile strength.

MR. TIMMINS said it was quite possible that variations in the iron were produced in the furnace. Working with Bessemer pig he had seen at 1 o'clock a No. 1 coming out, at 2 o'clock a No. 6, and at 6 o'clock a white iron. He had known men with 40 years' experience who claimed that by fracture alone they could judge iron as well as any analyst in the country, and he certainly found that to be borne out in the case of one man. Fracture grading was the quickest method, then analysis; grading by the microscope was much the longest.

MR. HARRISON claimed that the combination of chemical analysis and micro-copical examination would rule when grading by fracture had become obsolete. Merely looking at the iron did not disclose its composition.

MR. KEY said no doubt a man whose practical experience had taught him how to grade iron by fracture was a long way ahead of the man who relied upon analysis, but it took years to acquire the requisite delicacy of sight and touch. For his own part, he used a magnifying glass, and with it he could tell whether a pig was strong or weak. Anybody else could do the same. They could not do without grading by fracture: neither could they do without grading by analysis. On the whole, he thought the best method to arrive at the conditions and properties of iron was by uniting a technical knowledge of the chemical constituents with practical experience, aided by a magnifying glass.

MR. HARRISON asked whether it was not possible to have two irons identical in structure but different in chemical composition. In such a case, how could fracture be a satisfactory test?

MR. W. H. SHERBURN was particularly interested in Mr. Andrew's remark about the same compounds producing equal results under the same conditions. He was convinced that in spite of all that analysis or the use of the microscope could give them, there would always be need for the brains of the foundryman; they could not reduce things to such a mechanical level that the labourer could do everything that was necessary. Between the chemical analysis and the final test bar there was a great deal that called for the use of the brain—such as the condition of the sand, and the temperature of the pouring. It was not possible to work merely by analysis.

MR. MARKLAND pointed out that if the use of the microscope was to become general, a standard must be established in connection with the etching of the specimens examined. There must be an etching solution of a certain strength, and the specimen must be in it for a certain time. Everybody must be agreed on the procedure. The microscope in the future would come more and more to the front, but for the present he thought they must give the preference to grading by analysis; grading by fracture was uncertain.

MR. SIMKISS said a man accustomed to mixing his irons by fracture would get results equal to those obtained by a man accustomed to mix by analysis. Each method had its place. But in order to produce the best results the chemist must have some practical knowledge, and the practical man ought to understand analysis. Every foundry had its peculiarities, and what could be done in one might be impossible in another.

MR. WOLSTENHOLME explained that his method in using the microscope was to take three strips of metal, one from the top, one from the bottom, and one from the side, and etch them. It was impossible to use the microscope to examine a fracture, but that could be done with a magnifying glass.

MR. ANDREW, in reply, said the microscope was useful in examining the finished metal, and would, under standard methods, reveal differences not shown by ordinary chemical analysis. It would be interesting to know, however, how it would assist when producing the mixtures from, perhaps, four or more different irons. Usually they did not get a complete analysis; the ordinary analysis simply gave the graphite and combined carbon. There ought to be a grading of the graphite, whether fine or in patches as in mottled iron, or in flakes. It was not fair to say that one was the same as the other when, in fact, there was a difference in the size of the graphite flakes. The magnifying glass or pocket lens would very often reveal a difference in the fractures of two grey irons. One might show a continuous dark grey structure, the other a number of dark areas surrounded by a white matrix. Really on close inspection this iron would prove to be mottled, though not considered as such in the foundry. The appearance was probably due to higher phosphorus in the latter. The apparent discrepancies in the results obtained was sometimes due to the lack of a standard system of analysis. They might also be attributable to variations in the conditions under which the bars were produced, to some difference in the mould. While the man who graded by fracture could not transmit his knowledge to another person, the chemist could do so.

A vote of thanks to Mr. Andrew was passed.

Duplex Open-Hearth Furnace and Circular Furnace Door.*

As illustrated in Fig. 1, this type of furnace contains two hearths, being about 30 ft. in length and separated into two equal parts (h_1, h_2) by a partition of the same material as the hearth lining. Each hearth is provided with a taphole (a_1, a_2) and runners (r_1, r_2). The partition is about 4 ft. wide at the base and 1 ft. across at the crown, the slope on each face being curved to blend with the floor of the hearth. The height depends on the manner in which the flame is guided over the bath, but must on no account be so high as to encounter the flame direct, or the resulting upward deflection of the latter will soon destroy the arch. The height, moreover, can be adjusted while the furnace is running, any excess being easily melted off, and any deficiency made good by fusing material on to the crown until the proper height is attained.

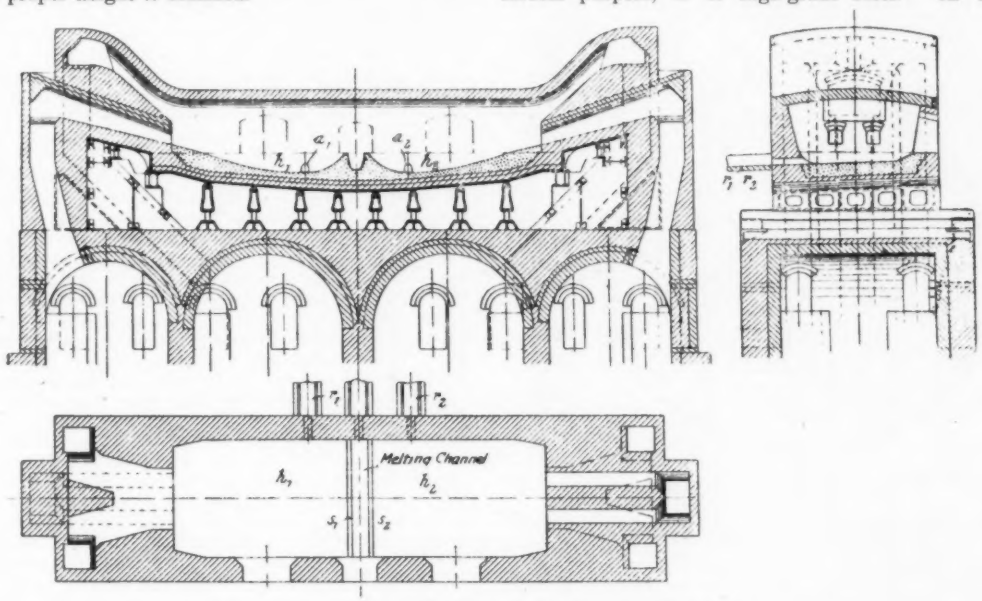


FIG. 1.—DUPLEX OPEN-HEARTH FURNACE.

The working of the duplex furnace presents no special difficulties; and the system has been in successful use for some time at the Westfälische Stahlwerke. The two hearths are charged in succession, but it is not necessary to tap them both at the same time or at a short interval, though it is advisable not to make the interval too long. Neither is it necessary to wait until the second hearth is emptied before recharging the first one; in fact, the recharging is commenced as quickly as possible, even though the second charge has only reached the sampling stage. If the furnace is running satisfactorily and is properly managed, it will deal with eight charges of about 18 tons each in 24 hours, unless specially high-grade steel is being made, in which event only six charges, three in each hearth, can be worked.

Any open-hearth furnace with a total hearth length of not less than 26 ft. can be converted into a duplex furnace, even while in work, if it has been provided with three tapholes, that is to say, one on either side the middle hole. This latter is covered up with magnesite blocks and rammed, when not required for use. The material for the partition is then fused on, and the two lateral tapholes are opened and fitted with runners. The whole operation can be completed in 36 hours, so that if undertaken at a week-end or on a holiday, the total time lost in the conversion will barely exceed that required for working one charge. The re-conversion to the single-hearth type can be effected in a corresponding period.

The success attained with the duplex system has induced the author to provide a melting channel in the crown of the partition (see Fig. 1), for melting additions, working small trial charges for experimental purpose, or of high-grade steel. In his opinion the steel made in this channel must be equal in quality to crucible steel, the charge being protected by the walls of the partition from the injurious action of the flame; and if the channel be made very narrow, it can be covered over, the melting being then conducted under conditions analogous to those in the crucible furnace. The output is comparable with that of a moderate-sized crucible furnace; and the arrangement offers the further advantage that additions can be made at any time; the charge can be stirred and specimens drawn until the desired quality is attained. Finally, by means of this channel, it is easy to tap off the slag from the main hearths.

Fig. 2 represents a circular door for open-hearth furnaces. It is of very simple construction and therefore inexpensive. The only fittings required consist of an iron band e, the ends of which are bent round at right-angles and tightened up by means of two bolts b_1, b_2,

*Translated from an article by R. Dietrich, in "Stahl und Eisen."

the upper bolt also serving to hang the door, whilst the lower bolt enables the band to be adjusted. The door itself is built up of radial blocks, arranged in several rings, r_1, r_2, etc., the number depending on the size of the door. A peep-hole, o, is left in the middle. In large doors the blocks are prevented from falling outward while in use by flat-iron stays, f_1, f_2, but these are unnecessary for small doors.

The advantage of circular (or elliptical) doors over other shapes is to be found not only in the simplicity and cheapness of the fittings, but also in the ease with which repairs can be made with a comparatively small quantity of material. As a rule, the doors of open-hearth furnaces—especially in the large furnaces now so extensively used—burn through very quickly in the middle; when such a door is taken out, the iron fitting invariably collapses, and the whole of the blocks are rendered useless, even such of them as have suffered little corrosion. Circular doors with adjustable fittings and made of radial blocks, however, do not collapse when the middle is burnt out,

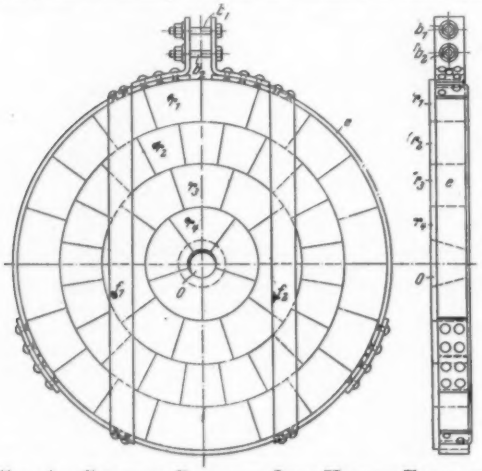


FIG. 2.—CIRCULAR DOOR FOR OPEN-HEARTH FURNACES.

each ring of blocks forming an independent structure, so that the middle can be replaced without the other outer rings having to be renewed as well. The circumstance that the iron fitting is adjustable also enables fireclay or silica blocks to be used as desired.

The National Physical Laboratory

The annual meeting of the General Board of the National Physical Laboratory was held recently at the rooms of the Royal Society, when the report and accounts for the year 1912 and the statement of work for 1913 were presented and approved for transmission to the President and Council of the Royal Society. In consequence of a change in the financial year the annual inspection will this year take place on Thursday, June 26, when the Right Hon. A. J. Balfour will open the new buildings recently erected.

These buildings complete a scheme initiated in 1909 to provide laboratories for metallurgy and optics, with administrative offices, at an estimated cost of £30,000, exclusive of equipment; of this sum the Treasury undertook to provide £15,000 provided the remainder were forthcoming from other sources. In 1910 the late Sir Julius Wernher generously provided £10,000 for the erection of the Metallurgy Laboratory, and on learning lately that the actual cost had exceeded the sum available by £936, Lady Wernher kindly defrayed the deficit. To secure the further sum necessary for the completion of the scheme, and to obtain funds for the equipment of the buildings, an "Additional Funds Committee," of which the late Sir William White was chairman, was appointed during 1912. In their report this Committee state that the Royal Commissioners for the Exhibition of 1851 had given a donation of £5,000 to the Building Fund, thus completing, with the gift from Sir Julius Wernher, the £15,000 required to meet the Treasury grant.

Help towards the equipment has been received from many sources, including a number of City Companies. The Committee, however, point out that considerable sums are still necessary to provide adequately the equipment which is essential for the proper development of the work.

Reports of Departments.

The work in the Engineering Department during the past year included general investigations on the effect of wind pressure on structures, the resistance of different forms of screw threads to shock, the resistance to tensile impact of materials under static stress, and reinforced concrete research. Among other work in this department were investigations on the efficiency of flat heat-insulating covers; tests on a series of nickel steels; investigations into cause of failure of a steel tyre; and an examination of specimens cut from cast-iron water pipes.

The Department of Metallurgy and Metallurgical Chemistry during the year has been largely concerned with the equipment of the Wernher Building, to which the work of the department was transferred in the autumn of 1911. The research work of the department has included the Alloys Research for the Institution of Mechanical Engineers. Progress had been made with the continuation of this research, and the work has consisted in the investigation of the ternary alloys of aluminium and zinc with copper, particular attention being given, in accordance with the general scheme, to the study of the light aluminium-rich alloys of the series. The experiments on the effects of strain at high temperatures, by Dr. Rosenhain and Mr. Humfrey, have been continued throughout the year. In the course of the work a very considerable number of disturbing factors were discovered, and practically the whole of the year has been occupied in tracing them. The research on brittleness in steel has been continued, and also that on the melting point of iron. The experimental difficulties of the latter research have proved exceptionally great, and it has been necessary to re-model the apparatus repeatedly. A considerable amount of investigatory test work has been undertaken for various Government Departments, notably the Board of Trade. The Advisory Committee for the William Froude National Tank report progress in all branches of the work. Fair progress has been made with the apparatus for testing model screws behind the ship models, but the most important work of the year is that with a series of models having the same principal dimensions, but with different distribution of the displacement in a longitudinal direction.

Proposed Work.

In the Engineering Department the work for the year 1913 is to include investigations regarding wind pressure on structures, and the resistance of different forms of screw threads to shock, general research on the methods of impact testing, research on fluid friction, and experiments on the resistance of keys and keyways to repeated stresses.

In the Department of Metallurgy and Metallurgical Chemistry the year's work will include a continuance of the Alloys Research. It is proposed to continue

the study of the light alloys of aluminium, and also to undertake an extensive investigation into the causes of spontaneous decay or disintegration which is said to occur in certain alloys of aluminium. The investigation of the effect of strain on steel at high temperatures, and the researches on intercrystalline cohesion in metals and the melting point of iron will also be continued. In metallurgical chemistry it is proposed to continue the research on the distillation of alloys *in vacuo*. Also, since it has repeatedly been suggested to the Laboratory that standard samples of pure substances to be employed for "setting" standard solutions and similar analytical purposes should be prepared and certified by the Laboratory with a view to their supply through chemical dealers or otherwise to analytical chemists throughout the country, it is proposed to commence work in this direction.

Making a Three-Part Job in Two Halves.

Although only a small job is taken to illustrate this principle, it is equally applicable to larger work, such as rope pulleys, flanged pulleys, etc. It is usual to make such work in three-part boxes, and as not many foundries have such boxes always available, it is easy to see what a great saving in both time and labour is secured by making the job in two parts instead of three, especially when a large number has to be made.

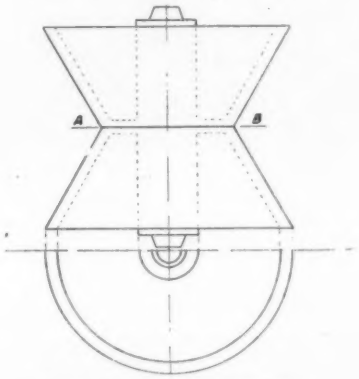


FIG. 1.—SHEAVE PATTERN.

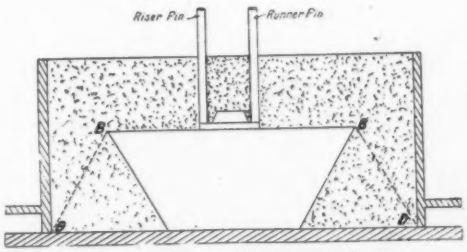


FIG. 2.—ONE HALF RAMMED IN COPE.

It is best to use a square box, 4 or 5 in. wider than the diameter of the job, and of sufficient depth to allow the sand plenty of grip. Fig. 1 shows a pattern of a sheave, the job that is here taken to express the idea. The pattern is made in two halves, jointed at A B. One half is rammed up in the cope, with runner and riser on the boss, as shown in Fig. 2, which also shows the position of the half-pattern when being rammed up. The cope is then turned over on to a board, and a joint made between B and the side of the box D, as indicated by the dotted lines in Fig. 2. This joint made, the other half of the pattern is then placed in position, and the space between the two is rammed up with good, firm sand, and stayed up with a few irons or long nails. This second joint is made between the top of the pattern and the side of the box, thus making a ring of sand round the middle of the pattern. This is shown in Fig. 3, the dotted lines indicating the ring of sand.

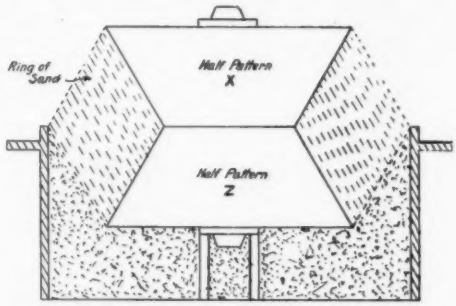


FIG. 3.—FULL PATTERN WITH RING OF SAND.

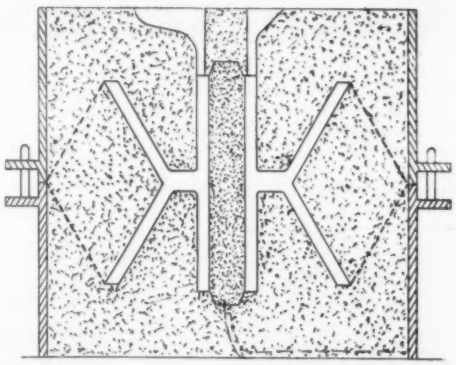


FIG. 4.—FINISHED MOULD.

The drag is next put on, rammed up, and lifted off, and in this case, at the same time drawing with it the half-pattern marked X in Fig. 2. If there is not enough sand round the job to take the weight while it is being lifted, it can easily be secured to the box. Of course, in heavier work the pattern does not need to be lifted; this is to be left to the discretion of the moulder. This half of the pattern having been now drawn out, and that part of the mould finished off, the drag is returned to its place. The whole box is turned over on to a soft bed, thus reversing the position of the ring of sand, and placing the drag and cope in their right positions.

It is easy to be seen what remains to be done. The cope is lifted off, and the Z half of pattern withdrawn, exposing the ring of sand lying on the bottom joint. It hardly needs explaining that this ring of sand serves in place of the middle part of a three-part box. Fig. 4 shows a half-section of the mould when finished.

Foundry Plant and Equipment.

A New Moulding Machine for Shallow Work.

The moulding of shallow work, especially round and oval pieces of small dimensions, such as saddlery, small rings, etc., and the moulding of rather large sections consisting of numerous small parts, such as stove plate and other ornamental work, fretwork, and similar work, offers difficulties of a special character. For this class of work it is necessary to do away almost entirely with the joint fin, owing to the practical impossibility of chipping every and any casting; consequently, it is of the greatest importance that the two half moulds should match perfectly.

Hand work is generally done at a good speed with improved processes, and machine moulding to be an improvement on hand methods not only must be quicker but must also give castings which are at leats equal to those made by hand. All these conditions render the production of this class of castings extremely difficult.

Among the methods of machine moulding employed for such work, the following may be mentioned as being the most common :—(1) Moulding on carded patterns on sand match. plates with a power

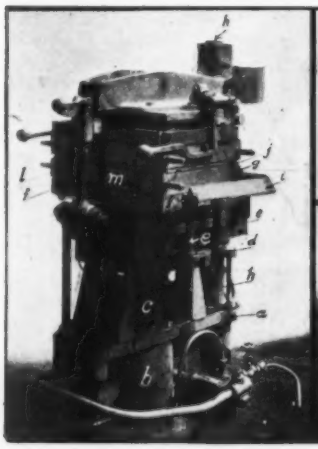


Fig. 1.—During the Ramming.

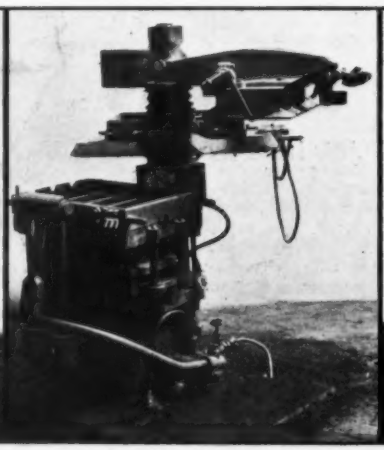


Fig. 2.—Machine with Boxes in Place before Filling with Sand.

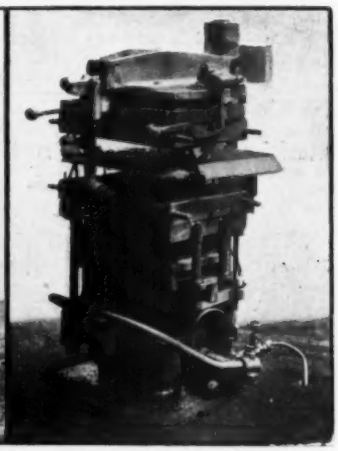


Fig. 3.—Pattern Drawn.

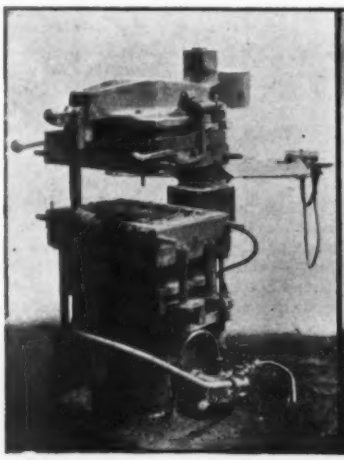


Fig. 4.—Pattern Plate Swung Away.

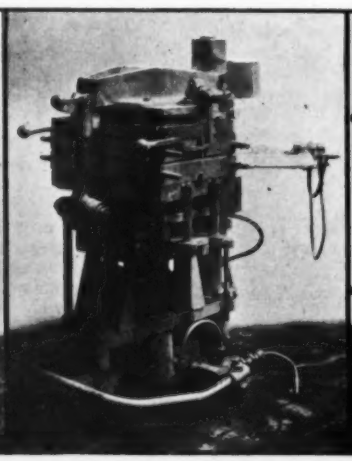


Fig. 5.—Mould Closed.

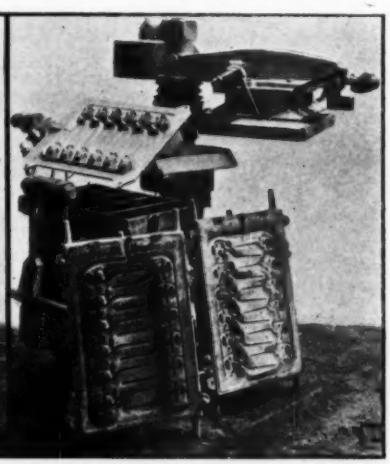


Fig. 6.—Mould Opened and Pattern-Plate Tilted to show Class of Work.

squeezer. This work is generally made on the flat in snap flasks. (2) Moulding on aluminium match plates with a power squeezer, generally in snap flasks. (3) Moulding in open sand on double-faced cast-iron plates, or on two separate plates (Leeder machine), the sand being pushed out of the flasks, which are part of the machine. (4) Moulding in flasks or in "mottes" with two pattern plates, one for the cope, the other for the drag.

moulding with double-faced plate, or on two separate plates, is by many considered only suitable for common work. In most of the above cases pouring has to be done on the flat. On the Continent it is very common to pour small castings on end, and this has many advantages, and makes it possible to put many more castings in one flask than when pouring on the flat.

If two separate pattern plates are used, it is

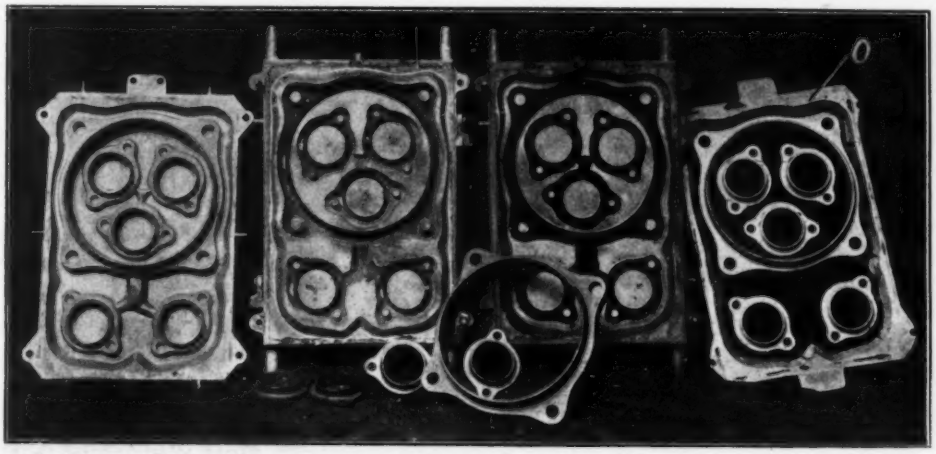


FIG. 7.—PATTERN-PLATE, MOULD DUMMY AND PIECES OBTAINED ON MACHINE SHOWN IN FIGS. 1—6.

These various processes have certain inconveniences. The carded pattern is very expensive, and always of small dimensions, its size being limited on account of its price; and it is impossible owing to its very nature to make it larger. On the other

practically impossible to obtain a perfect match. With regard to the cast-iron double-faced plate, this plate is costly owing to the necessity of making it strong enough to withstand the whole pressure of the machine, the ramming of both flasks being done

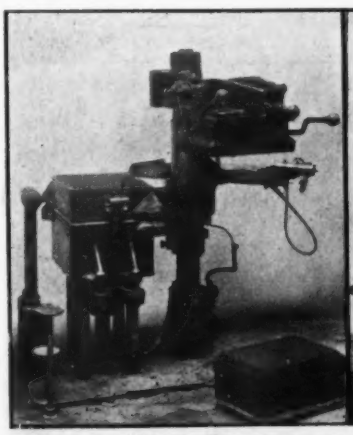


FIG. 8.—MOULD FINISHED AND MACHINE READY FOR ANOTHER.

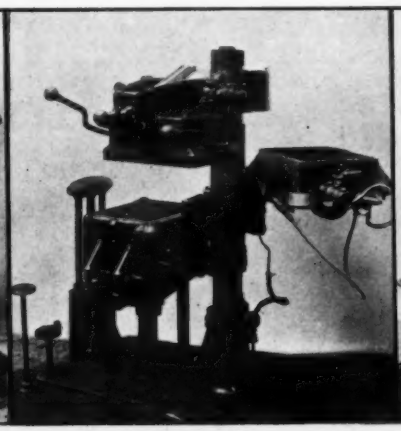


FIG. 9.—BOXES FILLED WITH SAND.

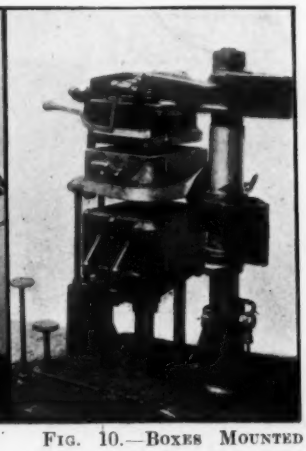


FIG. 10.—BOXES MOUNTED OVER ONE ANOTHER, THE TRAVERSE CLOSED AND LOCKED.

hand, if the castings are very thin, the vibration of the frame has no action on these small pieces, so that its adoption in such cases does not give very good results. Moulding with loose patterns on sand match is only practicable for very simple work, while

separately and not simultaneously. Moulding on separate plates with only pins for registering is very risky for the class of work under consideration, for while it is possible under the best conditions to obtain a perfect match, it is rather difficult to main-

tain such conditions in the every-day work of the foundry; in fact, most of this work has been made up to now by hand-moulding, which permits, under favourable conditions, of obtaining perfect work, though not very quickly.

The Société Anonyme des Etablissements Ph. Bonvillain & E. Ronceray, of Paris, of which the Universal System of Machine Moulding and Machinery Company, Limited, 97, Queen Victoria Street, London, E.C., are agents for the British Isles, which has for some time had on the market machines for complicated work, has recently designed and built a machine, patents for which are pending, which suggests a considerable step forward for the class of castings referred to above. With this machine it is possible (1) to fill both flasks simultaneously, (2) to ram the two flasks by only one stroke, (3) to draw the pattern by the machine, while the plate vibrates, (4) to close the mould on the machine, either for pouring on flat or on end, (5) to use barred flasks, and (6) to use a white-metal pattern plate of about ½ in. thickness, requiring no machining work, and made in about the same time as a sand match.

This pattern plate is produced by a carefully-made mould in a special flask, having a perfect match, and spacing the flask by a frame which makes the outside part of the pattern plate. During the ramming, the pattern plate is quite free from lateral fastening, being only guided by the flask pins. The speed is considerable, while the mould is entirely made on the machine, including the pattern drawing. The proper employment of bars renders it possible to use comparatively shallow flasks even for a large size, and does away with the necessity of weighting them all for pouring on flat, or of using the screw press when pouring on end.

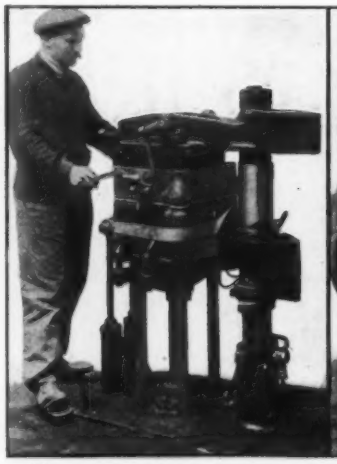


FIG. 11.—SIMULTANEOUS RAMMING OF THE TWO BOX PARTS; OPERATOR HOOKS UPPER BOX.

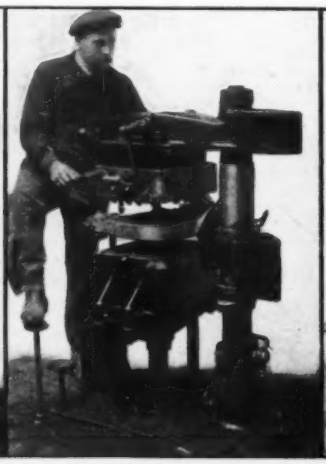


FIG. 12.—VIBRATOR SET IN ACTION.

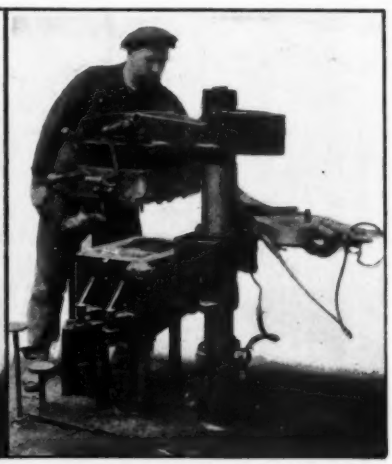


FIG. 13.—PATTERN-DRAWING FINISHED AND PATTERN-PLATE SWUNG AWAY.

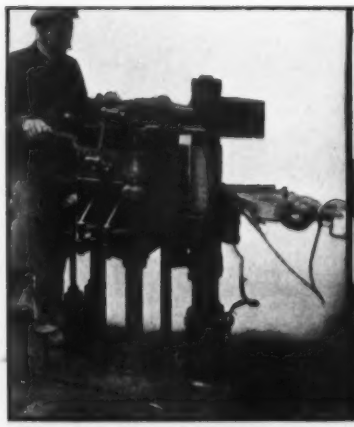


FIG. 14.—MOULD ASSEMBLED; OPERATOR UNHOOKS UPPER BOX.

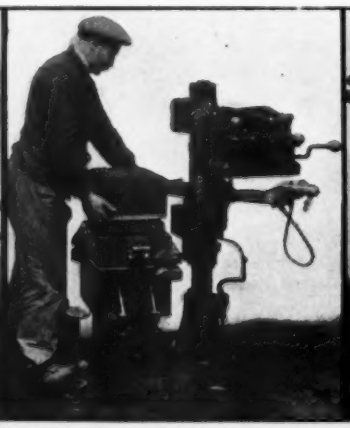


FIG. 15.—BOXES LOWERED AND SAND BLOCK PUSHED OFF.

FIG. 16. SAND BLOCK OPENED.

The machine is generally worked by hydraulic power for the principal operation, while the vibration is effected by compressed air; but by the use of a small intensifier compressed air can also work the whole machine. The machine is shown in the accompanying illustrations. It consists of a strong base (*a*, Fig. 1) bored in the centre to form the ramming cylinder (*b*). Down this cylinder is bolted another one receiving a smaller ram, the object of which is to perform quickly all the auxiliary motions, including bringing the flask together and closing the mould. This cylinder is not shown, as it is under the floor level. The main ram (*c*) is intended to give the ramming pressure. It is bored to receive a smaller one, at the end of which is bolted a plate (*d*) supporting through tie-rods (*e*) the down sand frame (*f*) shown under the lower flask (*g*). This ram is supported by air pressure, and its purpose is simply to support the down sand frame on a collapsible support.

On the side of the machine is a column (*h*) supporting a revolving bracket (*i*) for the pattern plate (*j*), and a cross-beam (*k*) which can be fixed to the frame of the machine by a hook (*l*). The pattern plate (*j*) is laid down on the bracket (*i*) through convenient means, and can be raised through the lower flask. Suitable means are provided for suspending the cope of the ramming plate bolted to the cross-beam.

The working of the machine is as follows:—The cross-beam being swung to the right, and the pattern plate with its bracket on the left (Fig. 2), one of the men fills the drag, and the other one the cope, the drag being placed on the down sand frame, and the cope on the pattern plate. The cope man swings the bracket so as to bring it opposite to the drag, while the drag man swings the cross-beam, and puts the hook in position. Immediately the drag man presses the treadle so as to admit water in the small cylinder, the whole equipment is raised quickly, the pattern plate and the cope being caught in passing by the drag, until the cope comes in contact with the upper ramming plate (Fig. 1). During this motion, the main cylinder has been put in communication with the tank and has been filled with water. By pushing the treadle a little bit further, the communication between the large ram and the tank is cut, and pressure water admitted. The cope man starts the vibrator, while the drag man hooks the cope. He then leaves the treadle, and the drag proceeds downwards with the pattern plate (Fig. 3). The pattern plate stops by itself on touching its bracket, while the drag lowers further, and a complete pattern drawing is then effected on the machine, while the vibrator is in operation. The cope man then stops the vibrator, and swings the bracket out with the pattern plate (Fig. 4), the drag man presses the treadle, admitting the pressure on the small cylinder, then closing the mould (Fig. 5). He then unhooks the cope and leaves the treadle. The complete mould proceeds downwards and is ready to be put on the floor.

The flasks generally used on the machine are fitted with hooks (*m*, Figs. 1 and 2) set so that as soon as the mould is closed the operators by a very simple motion hook them. The gates are made in a simple way, practically without the intervention of the operators.

As indicating the speed obtained, it may be said that it usually takes less than a minute on an average to make a complete mould. In practical working, the average time has been 45 seconds. Moving pictures taken of the operation under practical working conditions have made it possible to analyse the operation, and we give below a table showing the time taken for the various motions:—

High-speed Moulding Machine.

Description of Operation Moulding Drag and Cope. (Hardware Castings, Malleable) Barred Flask, 21½" × 14½"; 2½" drag and 2½" Cope.

Operator.	Seconds.	Fractions of Minutes.	Fractions of Minutes	Seconds.	Helper.
Pick up drag and put it in place ..	1.9	0.032	0.174	10.4	Blow off pattern plate. Swing sand frame above cope, shake parting and riddle sand on pattern.
Fill up drag (2 shovelfuls) and put sand in riddle ..	6.4	0.107	0.115	6.9	Fill up cope (2 shovelfuls).
Riddle sand on drag top	9.0	0.150	—	—	
Strike off surplus sand	4.5	0.075	0.075	4.5	Strike off surplus sand.
Swing on the pressing head and lock it..	1.8	0.030	0.123	7.4	Swing on pattern plate with cope on.
Squeeze and hook cope	5.5	0.090	—	—	
Draw pattern plate and finish gate holes with fingers..	7.7	0.130	0.093	5.6	Start vibrator.
Apply pressure to close mould and unhook cope ..	1.9	0.031	0.065	3.9	Swing out pattern plate and put cope on.
Release pressure, spring out pressing head and lock finished mould ..	1.8	0.030	0 030	1.8	Lock finished mould.
Place mould on floor (on end)	4.5	0.075	0.075	4.5	Place mould on floor (on end).
Total ..	45.0	0.750	0.750	45.0	

Number 7 riddle.	lbs.
Weight of an empty shovel	6
Weight of sand in shovel	22
Number of shovels in each part of flask two	44
Weight of sand in the two parts of flask	88
Weight of the two empty parts of flask	82½
Total weight of filled flasks..	170½

It must be borne in mind that no automatic sand distributor has been used, the men shovelling the sand from a heap. This machine is now in successful operation, 45 of them having been delivered in less than a year.

One may think that only very flat work can be produced by printing the drag. The difficulty of printing has been overcome to a great extent through the use of what the originators call a "dummy." The dummy (Fig. 7), in short, is a piece of metal (*o*) having holes corresponding to the projections of the mould to be made. The dummy being placed on the drag side, sand is riddled on it, and projections of riddled sand are left in places corresponding to the openings. This accessory is made in a very simple manner, being merely moulding work.

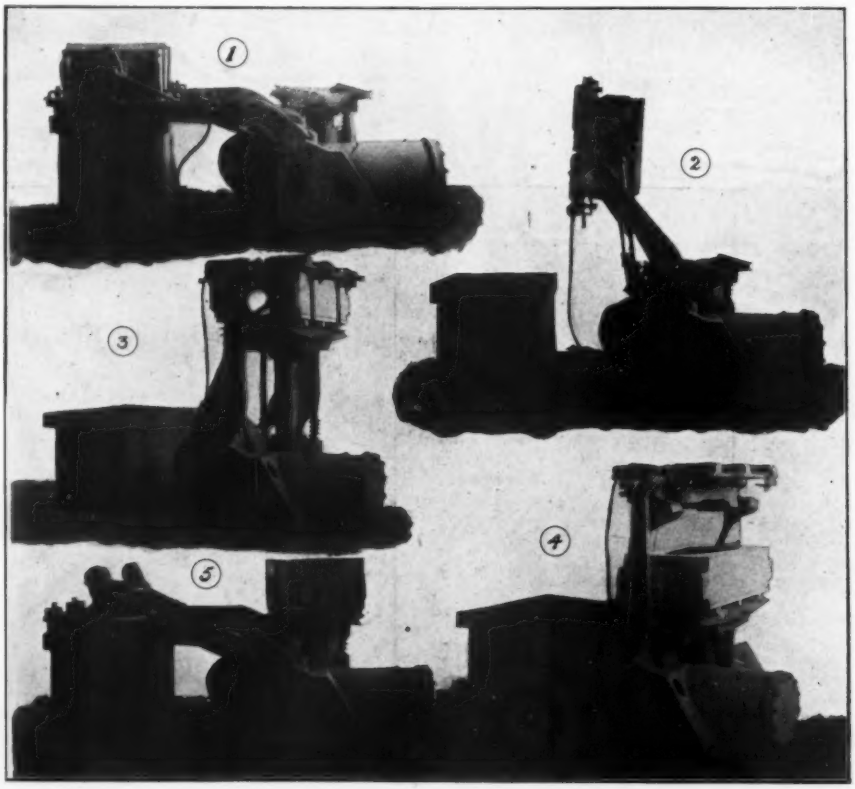
More recently a machine has been put on the market, derived from the above, which does exactly the same work, and in addition permits of pushing out the "mottes" on the machine immediately after the mould is completed. If the size of the "mottes" is limited to what a man can handle, the machine can be attended by only one operator, and can work at the same speed as the above, thus producing a mould measuring about 16 in by 12 in. in less than a minute. Figs. 8 to 16 represent some views of this machine.

Both machines were shown in operation at the French Foundry Exhibition, which concluded last

month. The first machine was shown in October last at the Olympia Machinery Exhibition in London; the second one will be on view at the Agricultural Hall, London, this month, at the Foundry Trades Exhibition.

New Jar-Ram Rollover and Pattern Drawing Machine.

The jarring moulding machine with an independent rollover and pattern-drawing device shown in the accompanying illustrations, has just been placed on the market by the Herman Pneumatic Machine Company of Zelienople, Pa., U.S.A. The purpose of a machine of this character is to give a good rollover action, and a perfect pattern draw. The machine is operated entirely by compressed air.



HERMAN JAR-RAM ROLLOVER AND PATTERN-DRAWING MACHINE.

Fig. 1 shows the jarring machine independent from the rollover device. The connecting arms that extend from the rollover mechanism engage trunnions on the rollover plate, which rests on the jarring machine. The pattern and flask are secured to the rollover plate. The jarring of the mould is proceeded with, and while the jarring operation takes place, the side rollover arms remain stationary. After the mould has been jarred, air is applied to the rollover cylinder, which causes the rollover plate, together with the flask, to rise, when the lifting arms engage the rollover. The rollover action is accomplished by a small arm which is connected to the trunnion on the rollover plate and the fixed centres of the base of the rollover device. These centres, being somewhat shorter than the centres on the large arm, cause a rotating movement to the rollover plate as shown in Fig. 2. This rotating action continues until the stop on the rollover plate trunnion comes in contact with the equalising and levelling device with the large rollover arm, which gradually brings the flask and rollover plate to rest, as shown in Fig. 3. Air is now admitted to the pattern-drawing cylinder, the upper part of which is attached to the equalising device used for taking up irregularities on the bottom board.

This pattern-drawing cylinder rises until it meets the flask. The clamps are then removed, and as the rollover plate is held in a firm position, the vibrator which is attached to the rollover plate is started, the air, exhausting from the pattern-drawing cylinder, allows the plunger to descend as shown in Fig. 4. By exhausting the air from the rollover cylinder, the rollover plate with pattern is returned to its first position, as shown in Fig. 5. Fig. 2 shows clearly the rollover device has no connection whatever with the jarring feature, thus rendering the rollover device serviceable for a longer time than it would ordinarily be, were the rollover mechanism connected directly with the machine; and the pattern is thus drawn accurately.

The machine shown has a table of 30 by 45 in., and a lifting capacity of 5,000 lbs., while the rollover device has a capacity of 4,000 lbs. The automatic self contained control valve, attached to the jarring machine,

regulates itself automatically to the different loads it is required to lift. This valve is of a differential type, and is entirely closed. Its operation does not depend on any external or exposed operating parts. The equalising device is of a very simple construction of steel beams hung on one centre, thus ensuring motion in all directions, which will take up irregularities on any bottom boards. Referring to Fig. 3, the makers claim special advantages for the semi-eliptical springs which are used for locking the equalising device after it is pressed against the bottom board by the action of the pattern-drawing cylinder. This construction locks the equalising device tight enough, so that the weight of the flask cannot change it, once it is set.

Apparatus for Keep's Test.

Keep's test for contraction and chill is well known to those foundrymen who realise the value of physical tests in analysing the properties of iron.

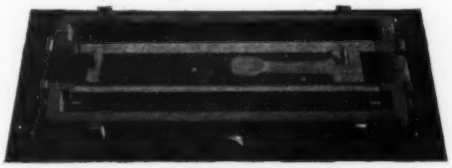


FIG. 1.

FIG. 2.

The accurate determination of contraction and chill, in fact, has taken its place as a standard foundry test.

An apparatus for accurately performing these tests is being supplied by Messrs. J. W. Jackman & Company, Limited, Caxton House, Westminster, S.W. The apparatus consists of an iron follow board carrying two brass patterns, each ½ in. square × 12 in. long, and also two special metal yokes for measuring shrinkage and chill, as shown in Fig. 1; an iron flask, as shown in Fig. 2; and a taper steel scale, graduated to measure to a thousandth part of an inch.

In this apparatus advantage is taken of the fact that contraction is greater in the direction of the length than in the depth and thickness, and chilling is obtained by casting the test pieces in the frames or yokes. At the same time, by casting the test pieces in the yokes, test pieces are cast with definite dimensions and having ends parallel. These test pieces can be gauged, and the amount of contraction quickly determined.

The yokes on the follow board are well rammed up in the drag of the mould, the patterns being fixed inside the yokes. Fine sieved sand is used, and the yokes are oiled previous to using. The gated patterns are withdrawn without rapping, and any sand falling between the ends of the patterns and the chilling surfaces is removed. No cleaning or blacking of the mould should be allowed. The flask should be weighted, and the metal poured clean, the test pieces being allowed to cool normally in the mould, and when removed, carefully cleaned and, if necessary, numbered for reference.

The test pieces, after cleaning, are laid in position in the yokes lying on the follow board, exactly as cast, with one pair of ends close up to one set of arms of the yoke. The space between the other ends of the test pieces and the corresponding yoke arms is the amount of total contraction. This space can be measured by inserting the taper scale vertically without pressure, and reading off the division, as shown in Fig. 4. This measurement gives the contraction per foot. It is imperative that the chilling surfaces of the yokes be kept smooth and true by grinding or filing. The chilling result is ascertained by chipping off a corner of the test piece.

FIG. 3.

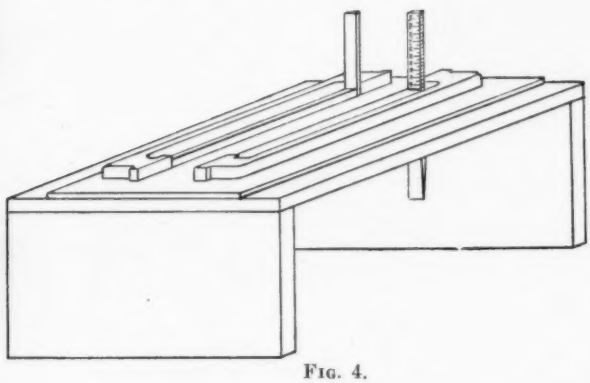


FIG. 4.

British Foundrymen's Association.

Birmingham Branch

At a meeting of the Birmingham Branch of the British Foundrymen's Association held on Saturday, April 26, Mr. H. L. Reason (President) in the chair, the following officers for the ensuing year were elected:—President, Mr. C. Heggie; Senior Vice-President, Mr. H. Pemberton; Junior Vice-President, Mr. D. Dalrymple; Hon. Secretary and Treasurer, Mr. Charles Grindlay; Auditor, Mr. Pugh. Members of the Council:—Messrs. Buchanan, Baugh, Howell, Morgan, Robinson, Toy, Hailstone, Bullock, Winterton, Shaw, and Reason.

A hearty vote of thanks was passed to Mr. G. Hailstone for his services in past years as Hon. Secretary, and regret was expressed that pressure of work prevented his continuance in office. A vote of thanks was also passed to the Treasurer and other officers and to the Council. At the conclusion of the business meeting a Paper on "Some Futher Notes an Moulding Sands" was presented by Mr. J. Shaw. This Paper appears on another page.

Annual Convention of British Foundrymen's Association.

The forthcoming annual convention of the British Foundrymen's Association, which will be held this month (June 21-25) in London, bids fair to be a most successful gathering. The headquarters of the Association will be at the Imperial Hotel, Russell Square, W.C., and the meetings will be held at Connaught Rooms, Great Queen Street, Kingsway. The official programme of the Convention includes the following:

Saturday, June 21.—Official visit to the First Foundry Exhibition, Agricultural Hall, London, N., and luncheon to the Members, at the kind invitation of the organisers of the Exhibition.

Sunday, June 22.—Thames River trip, on specially-chartered steamer, on which occasion each member is invited to bring a lady or friend.

Monday, June 23.—9.30 a.m.: Business meeting at Connaught Rooms, for the election of officers, etc., followed by general meeting for the presentation and discussion of the following Papers:—"Semi-Steel," by M. Riddell (Falkirk); "Blast Quantity and Pressure in Cupola Working," by F. J. Cook (Birmingham); "The Artistic Treatment of Cast-iron," by B. J. Fletcher (Leicester).

In the afternoon visits will be paid to the works of Messrs. Fraser & Chalmers, Limited, Erith, and to the Great Eastern Railway Company's Works, Stratford, E. In the evening the Annual Dinner of the Association will be held at the Holborn Restaurant, Holborn, W.C.

Tuesday, June 24.—9.30 a.m.: The meeting for the presentation and discussion of Papers will be resumed, and the following Papers will be considered:—"The Alloying of Aluminium," by C. H. Ivinson (London); "Electric Furnaces in Iron and Brass Foundries," by E. Kilburn Scott (London); "Standard Patterns for Motor-Car Work," by J. W. Worrall (Luton); and "The Economies of Industry and Education," by Alexander Hayes (London).

In the afternoon visits will be paid to the Royal Arsenal, Woolwich, and to the works of the London General Omnibus Company, Walthamstow. In the evening a visit will be paid to the London Coliseum Theatre.

Wednesday, June 25.—For members staying over Wednesday, a special visit can be arranged to the works of the London and South-Western Railway, Eastleigh, Hants.

Members desiring to participate in any of the foregoing functions are requested to advise the Hon. Secretary of the London Branch, Mr. T. Murphy, 180, Gray's Inn Road, London, W.C., at the earliest possible moment.

The Foundry Exhibition.

In regard to the Foundry Trades' Exhibition to be held at the Royal Agricultural Hall from June 14 to 28, a large attendance is anticipated in view of the interest already being shown. Heads of firms, managers, and foremen, in all parts of the country have intimated their intention of visiting the Exhibition. As an instance of the keen interest which is being taken, one firm in Derbyshire has chartered a special train for the purpose of enabling their employés to visit the Exhibition, and thus become acquainted with the latest machinery and appliances associated with foundry work. Nothing but good can come from an undertaking of this kind, and it is to be hoped that those who cater for the requirements of foundrymen, as well as those engaged in foundry practice, will take full advantage of this opportunity of improving the conditions under which the work is carried on.

Inventions.

Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

6,027.*Process of casting ingots and apparatus therefor. P. H. G. Durville.
6,067.*Moulding machines. W. Kurze.
6,165. Muffle furnaces. E. Curran.
6,166.*Metallic alloy and process of manufacture. H. O. Ormiston.
6,182.*Moulding-machine with elastic pattern support. R. Geiger.
6,286. Metal founding. (General Electric Company, United States.)
6,366.*Slab moulding machines. R. Girndt.
10,517. Casting-apparatus. F. G. S. Price.
10,482.*Centrifugal machine for the manufacture of foundry cores. M. Fauquet.
10,821.*Ingot moulds. W. D. Bradford.
10,853.*Regenerative open-hearth furnaces. T. B. Rogerson.
10,950. Regenerative furnaces. H. Walsh and A. Priestley, trading as Standard Furnace and Setting Company.
11,017.*Treatment of alloys to render them ductile and malleable. Westinghouse Metallfaden Gluhlampenfabrik G. m. b H.
11,091.*Manufacture of aluminium. Soc. Générale des Nitrures.
11,186.*Manufacture of moulding patterns. T. R. Bell.
11,190. Apparatus for casting metals in steel moulds. C. H. Ivinson and E. le Bas.

Abstracts of British Patent Specifications recently accepted.

4,619 (1912). *Manufacture of Steel.* S. M. Dixon, 25, Highfield Road, Edgbaston, Birmingham.—Five tons of mild steel scrap and manganiferous pig-iron are melted down in a Siemens furnace, and when the carbon has been reduced to the requisite percentage the bath is ready for the necessary additions. Ferro-manganese in the proportion required to give, for instance, ten per cent. of manganese in the finished product is added. This amount would be from about 1,800 to 2,200 pounds, assuming a ferro-manganese is employed containing 80 per cent. of manganese, the actual amount employed depending on the temperature, time of treatment, and other factors which have to be taken into consideration in ordinary foundry practice, and according to which the loss or absorption of manganese varies considerably. The ferro-manganese should be heated to a bright red heat and added to the bath while in this condition so that the large mass of metal in the bath will rapidly raise the comparatively small quantity of ferro-manganese to the same temperature as the bath itself, and no chilling of the latter will take place. Ferro-silicon to give the desired content of silicon is added, directly the melter has ascertained that the ferro-manganese has been properly assimilated. The metal is teemed immediately after the addition of the silicon. Into the ladle, previously heated to a dull red heat, the metal is now poured, and 50 pounds of powdered metallic titanium is added to the ladle while the pouring is in progress. The ingots are preferably cast from the bottom, the size of the aperture of emission from the ladle being in a proportion of as 5 is to 4 to the aperture of emission from the bottom of the "git." The ingots moulds should be coated internally with a slurry of graphite, and after this has been done, should be heated sufficiently to avoid any moisture remaining in the moulds. When stated proportionately the above materials employed are approximately as follows: Pig-iron and scrap, about 83 to 85 per cent.; ferro-manganese, about 16 to 13 per cent.; and titanium, about 4 per cent. If ferro-titanium is employed instead of metallic titanium about 240 pounds of ferro-titanium containing about 22 per cent. of titanium is added to the bath or ladle.

6,310 (1912). *Mode of and Means for Finishing Sand Moulds for Casting Purposes.* William Mills, Limited, and W. Mills, Atlas Aluminium Works, Grove Street, Smethwick, Birmingham.—Fig. 1 illustrates one form of the invention; Fig. 2 is a side elevation of Fig. 1 showing holes in the table for bolting on the mould; Fig. 3 is a sectional elevation illustrating another form of table and stand; Fig. 4 is a sectional side elevation of a modified form of the invention. A table 1 is supported upon a suitable stand 2 by a swivelling connection 3, such table being arranged at an angle of about 45 deg., so that as the table is rotated all parts, both vertical, circular and horizontal, present their surfaces in such a manner as to enable the facing material when dusted on to remain equally on all parts of the surface, and which also facilitates the process of smoothing which may be effected by the fingers, which are preferably covered with thimbles of fine skins of india-rubber. In Fig. 3 provision may be made whereby the table can be turned and secured in a horizontal position for use when forming the mould and suitable means are provided for retaining the mould 4 on the table when in its tilted position, such for instance as projecting rods 20, which enter the ordinary holes in the lug projections 21 on the mould, as shown in Fig. 4, or by having a raised flange or projection 5 on the table, within which the lower portion of the mould fits as shown in Fig. 1. In

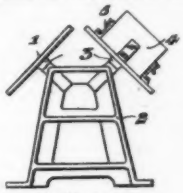


FIG. 1.

FIG. 2.

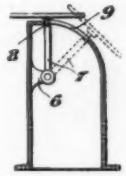


FIG. 3

FIG. 4

Means for Finishing Sand Moulds for Casting Purposes.

the case of a table mounted to take both the horizontal and inclined positions as shown in Fig. 3, a suitable cast-iron stand may be provided of inverted U-shape to the one interior side 6 of which the lower end of a lever 7 is pivoted. The upper part of this lever is either tubular or provided with bearings within which the spindle 8 of the table is free to rotate, a slot 9 being formed in the one side of the top of the stand so as to enable the table to be turned on the pivot of the lever from the horizontal to the inclined position, or *vice versa*, as the case may be. Provision is made for locking the table in its horizontal position.

4,620 (1912). *Manufacture of Steel.* S. M. Dixon, 25, Highfield Road, Edgbaston, Birmingham.—The invention is based upon the discovery that the titanium when used in the process of founding manganese steel has an effect upon the structure of the steel which is not based upon the formation of a final alloy of titanium, but which is the result of chemical or physical action, for when titanium is used the resulting finished metal will have its structure so modified as to be readily capable of being worked even though no titanium is to be found in its composition. To manganese steel in the molten state, containing between 7 and 22 per cent. of manganese is added, according to the character of the steel, time of treatment, temperature, etc., from 30 lbs. to 120 lbs. per ton, of ferro-titanium containing about 22 per cent. of titanium or an equivalent proportion of metallic titanium, which is thoroughly incorporated with the steel. The titanium has in the molten state a refining action upon the manganese steel and in the course of the operation may be entirely lost, although it has had upon the structure of the steel the desired effect.

New Companies.

Carden Engineering Company, Limited.—Capital £2,000 in £1 shares.

Lamp Pump Engineering Company, Limited.—Capital £1,000 in £1 shares.

James Dawson & Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of engineers.

Anderson and Partners, Limited.—Capital £1,000 in £1 shares, to carry on the business of engineers.

Commercial Oxygen, Limited.—Capital £5,000 in £1 shares. Registered office: 1, Staple Inn, Holborn, W.C.

Structural Patents, Limited.—Capital £10,000 in £1 shares (5,000 pref.), to carry on the business of engineers.

Thompson & Southwick, Limited.—Capital £20,000 in £1 shares (15,000 Pref.), to carry on the business of engineers.

Tylecroft Engineering Company, Limited.—Capital £2,000 in £1 shares. Registered office: 58, Lombard Street, E.C.

Chester Engineering Company, Limited.—Capital £4,020 in 4,000 preference shares of £1 and 400 ordinary shares of 1s.

August's Muffle Furnaces, Limited.—Capital £2,250 in £1 shares. Registered office: Mear Clough Works, Sowerby Bridge.

Metallic Compound Company, Limited.—Capital £4,000 in £1 shares. Registered office: 265, Gray's Inn Road, London, W.C.

Chambon, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers. Registered office: 210, Tower Bridge Road, S.E.

Thomas Ryder & Son, Limited.—Capital £20,000, in £1 shares. Registered office, Turner Bridge Ironworks, Turner Bridge, Bolton.

James Lees, Limited.—Capital £1,500 in £1 shares (400 preference), to carry on the business of ironfounders. Registered office: 37, Bury Street, Salford.

Wood & Phillips, Limited.—Capital £4,000 in £1 shares, to carry on the business of engineers. Registered office: 9, High Street Buildings, Dorking.

Reycar Syndicate, Limited.—Capital £100 in £1 shares, to carry on the business of manufacturers, engineers, etc. Registered office: 48, First Floor, Broad Street House, E.C.

Ester & Company, Limited.—Capital £1,030 in 1,000 ordinary of £1 and 600 deferred of 1s. each, to carry on the business of engineers. Registered office: Caxton House, Westminster.

Currie & Warner, Limited.—Capital £7,000 in £1 shares, to take over the business of cabinet and general brassfounders carried on at Summer Hill Works, Powell Street, Birmingham, as Currie & Warner, and to adopt an agreement with F. G. Currie and H. H. Warner.

Leeds Engineering and Hydraulic Company, Limited.—Capital £20,000 in £1 shares, to take over the business carried on at Oaklands Works, Calverley, near Leeds, by the Leeds Engineering and Hydraulic Company, Limited (incorporated in 1902, now in voluntary liquidation), and to adopt an agreement with W. Deighton and H. Loxton (for the debenture-stock holders of the said old company).

Steel Developments Limited.—Capital £90,000 in 6s. shares, to carry on the business of iron and steel manufacturers, &c., and to acquire the undertaking and all or any of the assets of the Talbot Continuous Steel Process, Limited, (incorporated in 1900). The first directors are Mr. Rd. Armitage, M.P., Farnley, near Leeds; Mr. J. E. Rogerson, Mount Oswald, Durham; Mr. C. J. Bagley, Stockton-on-Tees; Mr. A. Sladden, Norton, Stockton-on-Tees; Mr. T. Westgarth, Scarborough; and Mr. B. Talbot, Darlington. Registered office: County Bank Chambers, Middlesbrough.

Trade Talk.

CONSIDERABLE damage has been done by fire to Messrs. Bamford's Leighton Ironworks, Uttoxeter, Staffs.

THE brassfoundry of Mr. Thomas Sanders, in St. Mary Street, Ladywood, Birmingham, has been seriously damaged by fire.

MESSRS. BERRY, SKINNER & COMPANY, have transferred their Scottish agency to Mr. J. Hally Craig, 45, Hope Street, Glasgow.

GREEN'S CHEMICAL ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. A. Greenwood, 20, Bond Street, Dewsbury, as liquidator.

THE CARLTON ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. Charles Osborn, 66, Mark Lane, London, E.C., as liquidator.

FRANK WIGGLESWORTH & COMPANY, LIMITED, have established works at Shipley, near Bradford, for the manufacture of power transmission appliances.

MESSRS. DENNY & COMPANY, engineers and boilermakers, of Dumbarton, have taken out a licence for the manufacture of Sulzer-Diesel oil engines in this country.

THE Council of Ministers at St. Petersburg have decided to place the contract for a new gun factory in Russia with the group of financiers associated with Vickers, Limited.

CREDITORS of J. H. Pyle, coppersmith and brassfounder, Glasgow, are to receive a second and final dividend, from Messrs. Davies, Tait & Company, 168, St. Vincent Street, Glasgow.

JAMES KEITH & BLACKMAN COMPANY, LIMITED, have opened a new office in the "Scotsman" Buildings, 28, North Bridge, Edinburgh, for the convenience of their clients in the east of Scotland.

MR. H. E. JACKSON, machine tool maker, of Church Gate, Leicester, has appointed Messrs Burns, Morrison and Company, 113, St. Vincent Street, Glasgow, agents, for the North of Ireland and Scotland.

THE partnership heretofore subsisting between Messrs. H. J. Cherry and A. Cherry, carrying on business as engineers, at Hill Street, Leicester, under the style of H. J. Cherry and Son, has been dissolved.

MESSRS. J. MAIR and A. GLENNIE carrying on business under the style of Austin & Company, as lift builders, engineers, and millwrights, at Dunn Street, Newcastle-upon-Tyne, have dissolved partnership.

WILLIAM MUIRHEAD & COMPANY, LIMITED, late of 35, Queen Victoria Street, London, E.C., have removed to 41, Parliament Street, Westminster, S.W. Mr. R. Macdonald Wilson, A.M.I.C.E., has been elected a director.

THE partnership heretofore subsisting between Messrs. J. Smith and T. Wilshaw, carrying on business as engineers' tool makers, at Hopwood Lane, West End, Halifax, under the style of Smith & Wilshaw, has been dissolved.

T. ROWLANDS & COMPANY, LIMITED, Palm Tree Works, Staniforth Road, Sheffield, who for some time past have represented the Titanium Alloy Manufacturing Company, Niagara Falls, N.Y., in Great Britain, have been appointed European agents for the company.

MR. R. A. CUMMING has taken over from Mr. Alexander McAulay, the sole surviving partner, the business of John Pollock & Company, engineers, machine toolmakers, and millwrights, 76, Lancefield Street, Glasgow. Mr. Cumming will continue the business under the same name.

MESSRS. H. SMITH and D. M. JOB, carrying on business as practical engineers and brass founders, at the Dynevor Engineering Works, Llanelly, under the style of Job and Smith, have dissolved partnership. Mr. D. Morgan Job will carry on the business under the style of David M. Job.

MESSRS. J. ACKROYD and J. BARKER, carrying on business as general smiths and mechanical engineers, at Cliffe Mills, Great Horton, Bradford, under the style of Ackroyd & Shackleton, have dissolved partnership. Mr. J. Ackroyd will continue the business under the present style of Ackroyd & Shackleton.

THE partnership lately subsisting between Messrs. J. Earnshaw, of Main Street, Bingley, and G. Lee, of Bingley, carrying on business as engineers, in Busfeild Street, Bingley, under the style of James Earnshaw & Company, has been dissolved so far as regards Mr. G. Lee, who retires from the firm.

THE partnership heretofore subsisting between Messrs. H. E. Hall, H. O. Hall, and F. Baring-Gould, carrying on business as engineers, at 90, High Street, Tonbridge, Kent, at Pantiles, Tunbridge Wells, and at 16 Prince of Wales Road, Norwich, under the style of H. E. Hall & Company, has been dissolved.

THE shareholders of the Bell Range & Foundry Company, Limited (in liquidation), will meet at Drury Chambers, Market Square, Northampton, on June 31, for the purpose of having an account laid before them, showing how the winding-up has been conducted and the property of the company has been disposed of.

THERE is every probability of a new engineering works being established at Chesterfield. We understand that Messrs. S. S. and A. Owen have been in communication with the Corporation with respect to the purchase of an extensive area of the Corporation's land, whereon to erect engineering works, and powers to complete negotiations for the sale have been delegated to a sub-committee.

THE members of the Junior Institution of Engineers have arranged a week-end excursion to Brussels for the purpose of visiting the Ghent Exhibition. The party will leave London on Friday, July 4, and visit the Exhibition on the Saturday. For Sunday and Monday excursions will be arranged to various places of interest in Belgium, the party returning to London at the close of the latter day.

THE shareholders of the Talbot Continuous Steel Process, Limited, have passed a resolution to the effect that it is desirable to reconstruct the company, and accordingly that the company be wound up voluntarily. Mr. Thomas Twynam, of County Bank Chambers, Middlesbrough, has been appointed liquidator for the purpose of such winding-up. The new company is styled Steel Developments, Limited.

THE proposed increases in the railway rates for the carriage of merchandise were announced on May 15, but can hardly be considered so moderate as the companies would have merchants and traders believe. From a perusal of the various announcements it will be seen that beginning with an increase of ½d. on existing rates up to and not exceeding 1s., and of 1d. up to and not exceeding 3s. 1d., the rates show the uniform increase thence onwards of 1d. for every 2s. up to 98s. 11d. of the present rates, the increase for the last named amount being 3s. 11d. and for all amounts above it 4s. The notices are identical, with the exception of that published by the London, Brighton, and South Coast Railway, which specifies higher rates between stations on the line which are not served by the London and South-Western or the South-Eastern and Chatham Companies. These charges show an increase of one penny on the present rate up to and not exceeding 1s. 6d. per ton, 2d. up to and not exceeding 2s. per ton, and 1d. for every 10d. per ton onwards to 35s. 4d. per ton, the addition to that rate being 3s. 6d. per ton. Where the present rates exceed 35s. 4d. per ton the increase amounts to 3s. 7d.

In Hamilton Sheriff Court, the trial has been concluded before Sheriff Shennan and a jury of Mr. T. M. G. Morton, manager, of Motherwell, on a charge of culpable homicide in connection with the boiler explosion at Allanton Foundry, Morningside, Newmains, on July 10, 1912, by which three workmen lost their lives. The evidence all clearly showed that the accused had not actually been appointed general manager of the company until after the explosion. The accused gave evidence on his own behalf, and stated that up to the registration of the new company he had simply gone to the works to "look on," as he had been instructed by his superior, Major Mellor. He had carried out the instruction, but he absolutely took no charge whatever of the plant. The jury returned a unanimous verdict of "Not guilty." The accused was accordingly discharged.

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COLONIES, AND FOREIGN GOVERNMENTS.

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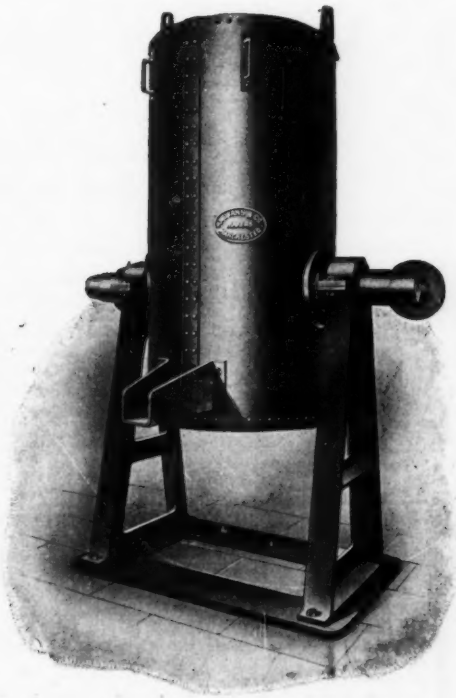

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

Personal.

MR. H. T. RINGROSE has been appointed an inspector of factories and workshops.

The late Mr. L. H. Bendall, of Messrs. Bendall & Son, ironfounders, left estate valued at £5,942 gross.

THE late Mr. R. T. Preston, a director of J. Stone & Company, Limited, of Deptford, London, S.E., left estate of the value of £91,415.

THE late Mr. W. Penman, a director of Penman & Company, Limited, left personal estate in the United Kingdom valued at £29,887.

THE personal estate of the late Mr. J. Roberton, formerly of Messrs. Cameron & Roberton, Star Foundry and Southbank Ironworks, Kirkintilloch, is £3,645.

THE late Mr. Robert Dempster, founder of the firm of Robert Dempster & Sons, Limited, of Elland, Yorks, left estate valued at £37,988 gross, with net personalty £37,826.

THE gross value of the estate of the late Mr. James Tangye, one of the founders of the firm of Tangyes, Limited, Cornwall Works, Smethwick, is £13,161, with net personalty £12,188.

THE late Mr. William Bullough, who was interested in Howard & Bullough, Limited, engineers, of Accrington, left estate of the gross value of £187,835, of which £186,652 is net personalty.

THE late Mr. F. Hobson, of Hobson, Houghton & Company, Limited, Don Steel Works, Sheffield, left estate of the gross value of £81,606 of which the net personalty has been sworn at £73,344.

THE late Mr. W. B. Railton, for many years a partner in Messrs. Railton, Campbell, & Crawford, engineers and ironfounders, of Walton, Liverpool, left estate valued at £4,249 gross, with net personalty £3,170.

MR. W. CLARK, who two or three years ago was appointed general manager of the Don Works, Sheffield, of Vickers, Limited, and who a year later became one of the special directors, has just been elected an ordinary director.

MR. S. C. OLDHAM, manager of the repair department at the Birkenhead establishment of Cammell, Laird & Company, Limited, has been the recipient of a presentation from the officials and men on the occasion of his leaving to take up a position with Messrs. Clover, Clayton & Company, Birkenhead.

Deaths.

MR. WM. MAXWELL, formerly works manager to Messrs. Campbell, Binnie, Reid & Company, engineers, at their Parkhead works, Glasgow, died suddenly on May 11 at the age of 62 years.

THT death took place on May 27, at Mount Pleasant, Macclesfield, of Mr. John T. Nicolson, D.Sc., M.Inst.C.E., Professor of Mechanical Engineering in the University of Manchester.

THE death took place on May 25, suddenly, at his residence, 215, Eccles New Road, Weaste, of Mr. John Allen, eldest son of the late Mr. William Allen, engineer, Great Ancoats Street, Manchester.

THE death took place at Belfast on May 11 of Mr. J. Megannety, who for 62 years was an employé in the Belfast works of Fairbairn, Lawson, Combe, Barbour, Limited. He started at the works as a boy, and rose to the position of manager.

THE death was announced on May 12 of Mr. Hugh Dunsmuir, of the firm of Dunsmuir & Jackson, Limited, Govan Engine Works, Glasgow. Mr. Dunsmuir was in his 72nd year. In 1877 he joined with Mr. Jackson in establishing the firm of Messrs. Dunsmuir & Jackson, which now employs about 1,000 men.

THE death occurred at Folkestone on May 25 of Mr. G. H. Baines, of West Hartlepool. Mr. Baines, who was in his 70th year, was a native of Leicester, and went to West Hartlepool about 35 years ago to fill an appointment at the Central Marine Engine Works of Messrs. Wm. Gray & Company, and at the time of his death was managing director of that concern.

SIR JAMES B. SMITH, of Clifford Park, Stirling, died on May 10. Sir James was born at Jackson, Mississippi, U.S.A., 69 years ago, his father being the late Mr. James Smith, of Dowanhill, Glasgow, a partner in the firm of Smith & Wellstood, Limited, Bonnybridge. Educated at Dollar Academy and the Andersonian College, Glasgow, Sir James entered the family business, where he remained for 30 years, retiring in 1888. He continued to hold, however, directorships in the Kilsyth and Bonnybridge Railway Company, Smith & McLean, Limited, and other companies.

WE regret to announce the death of Sir Charles John Stoddart, V.D., J.P., which occurred on May 24, at his residence, Blenheim House, Rotherham. Colonel Sir Charles J. Stoddart, V.D., J.P., was born in London on October 8, 1839, and received his education at Christ's Hospital. When he reached the age of 15 years he commenced his business career in the City office of Messrs. Samuel Beale & Company, who were then the proprietors of the Parkgate Ironworks, Rotherham. About 1864 the firm was converted into a limited company, and Mr. Stoddart, who had continued to make rapid advancement, settled in the Parkgate district. The offices of the company were removed to Parkgate and Mr. Stoddart became first secretary and eventually managing director. He advised his board to embark in the steel trade, and from designs which he made a plant was installed on the very newest lines. Late in life the King recognised his worth by conferring the honour of knighthood upon him. Sir Charles also became associated with the Dalmellington Iron Company, Limited, the Staveley Coal and Iron Company, Limited, the Wagon Finance Corporation, Limited (of which he was one of the founders), and other important concerns.

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AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

You have no need to experiment in Foundry Plant. We have bought this experience, and guarantee everything we offer. Our special catalogue,

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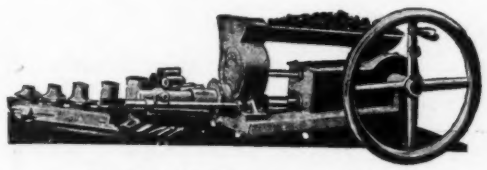
contains the best. Contracts completed and duly inspected for H M. Dockyards, include Sheerness, Portsmouth, Devonport, Pembroke, Greenock, Gibraltar, Malta, Hongkong, The War Office, Crown Agents for the Colonies, South Australian Government, The Italian and Japanese Navies, English Railways, Dock Harbour Boards, South American and African Railways. . . .



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Tilting Furnaces-Oil & Coke Fired, Moulding Machines, Core Machines, Sand Mixers, Ash Pulverisers & Washers, Mould Driers.

&c., &c.

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J. W. & C. J. PHILLIPS Ltd., 23, COLLEGE HILL CANNON ST., LONDON, E.C.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End May, 1913.	End May, 1912.
Iron—Scotch pig warrants ton	*74/-	*59/10½
—Middlesbro' warrants ton	61 6	54 0½
—W.C. Mines Bessemer ... ton	82/9	72/-
—Stock, Middlesbrough ...tons	241,385	1,000
Copper—Chili bars GMB ton	£67 15 0	£75 15 0
—Stock, Europe and afloat tons	44,201	52,500
Tin—English ingots ... ton	£219 10 0	£210 10 0
—Straits ... ... ton	£215 10 0	£204 5 0
—Stock, London, Holland, U.S.A., and afloat ...tons	14,663	15,184
Lead—English pig ... ton	£20 5 0	£17 0 0
Spelter—Ord. Silesian ... ton	£23 0 0	£25 15 0
Quicksilver (75lb)... bottle	£7 10 0	£8 5 0
Antimony—Regulus .. ton	£31 0 0 £33 0 0	£27 0 0 £28 0 0
Aluminium—Ingot ... ton	£92 0 0 £95 0 0	£67 0 0

*Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	7 7 6	to	7 12 6
Pipes, 1¼ to 2½ in.	6 12 6	to	7 0 0
,, 3 to 4 in.	6 5 0	to	6 7 6
,, 5 to 8 in.	6 0 0	to	6 2 6
,, 10 to 16 in.	6 2 6	to	—
,, 18 to 24 in.	6 2 6	to	—
Chairs	4 14 0	to	4 15 0
Floor plates (open sand)	3 10 0	to	3 12 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: Heavy wrought (mixed), £2 17s. 6d.; light wrought, £1 5s. 0d.; heavy cast, £3 3s. 6d.; all per ton, f.o.b., London. Copper (clean), £65 10s. 0d.; brass (clean), £44 10s. 0d.; lead (usual draft), £18 10s. 0d.; Zinc, £17 15s.0d.; all per tondelivered merchant's yards.

BLOFIL
THE
IRON CEMENT
(Quick or slow setting grades)
IS
THE CHEAPEST
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MOST RELIABLE
for all purposes.
Unaffected by oil, steam, or water.
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STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
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THERE IS NOTHING LIKE IT.
Proved by the leading firms to be absolutely reliable and holds an impregnable position in the foundry after all others have failed
"SPERMOLIN" (Regd).
Is used by all the leading firms in the making of Cores of Castings for Steam Engines, Turbines, Gas and Oil Engines, Motor Car Cylinders, Pumps of all descriptions, Machine Tools, Radiators, Sectional Boilers, Gas Stoves and Gas Rings, Malleable Iron Castings, Steel, Iron and Aluminium Castings.
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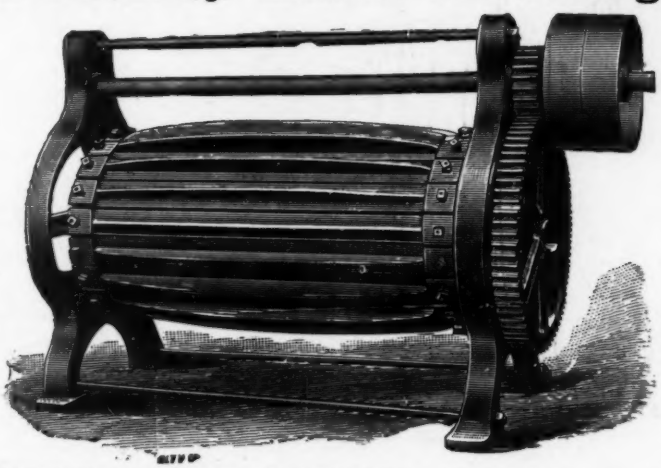
Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

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The "Tottenham" Portable Hot-Air Core Oven.

The Oven is built on a Scientific principle which causes a rapid circulation of hot dry air to pass round the cores. They are dried thoroughly right through; those on the top shelf being dried as quickly as those below. Burning the cores is impossible, as no flame or smoke comes into contact with them.

It is arranged for fuel or gas and is exceedingly economical in the consumption of either.

Call and see it.

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THE LONDON EMERY WORKS Co., PARK WORKS,

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YOUNG Man, 12 years as a practical Foundryman, and one year's experience as a Traveller, desires position as Midland Counties REPRESENTATIVE for a Firm of Foundry Requisite Manufacturers.—Apply Box 638, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

SMART, energetic MAN, with first class commercial experience and references, holding important post with Light Castings Founders, desires change.—Address Box 640, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

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for the purpose of making good holes in castings.

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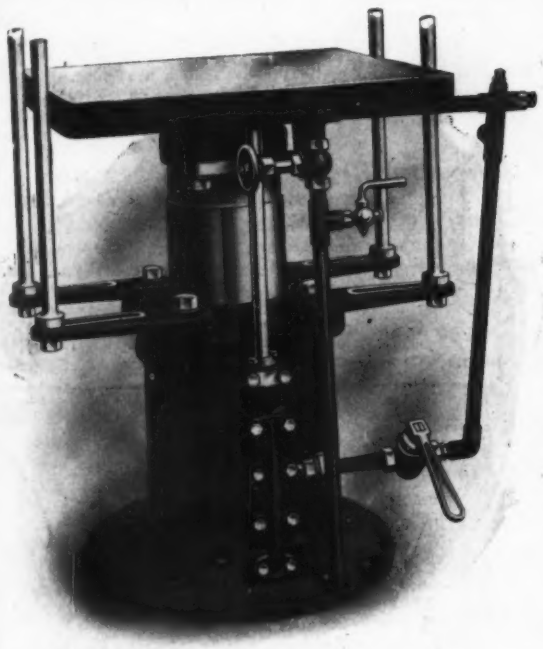
is doing everything to make it worth your while to pay their stall a visit and their representatives shall be there to discuss any commercial or technical point.



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JAR RAM MOULDING MACHINE

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Fitted with

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Now on view at

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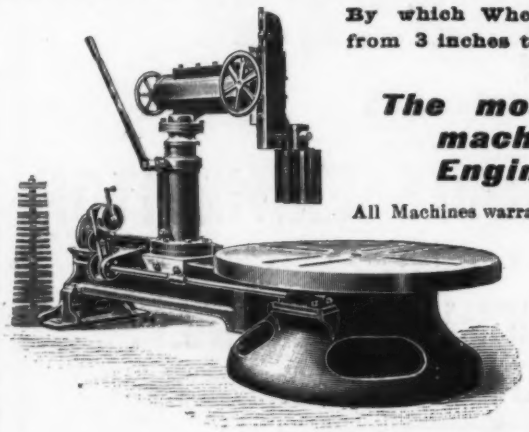
WHITTAKER'S IMPROVED MOULDING MACHINE



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The most complete and efficient machine hitherto introduced to Engineers.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

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NOTE THE FOLLOWING POINTS—

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2. Melts hot and exceedingly fluid and will fill every corner of your Mould.
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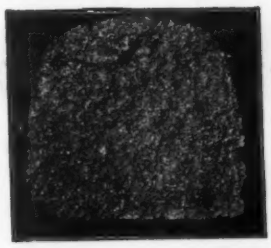
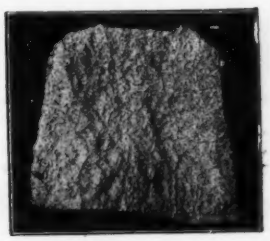
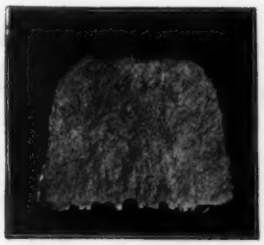

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Magnetic Separators remove Iron from Brass Turnings without waste.

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We claim that it is better than the best, and we are willing to prove this by forwarding a small tin to any responsible firm on unconditional approval.

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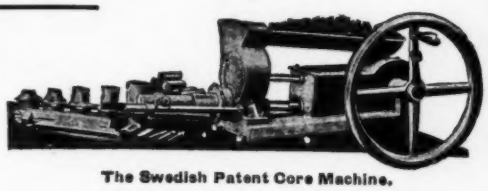
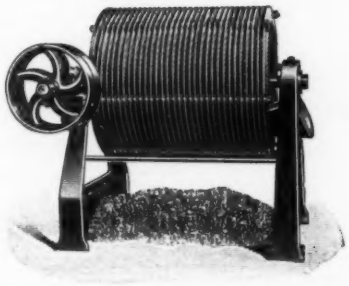


The Swedish Patent Core Machine.



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Before using Ironsteel Compound.

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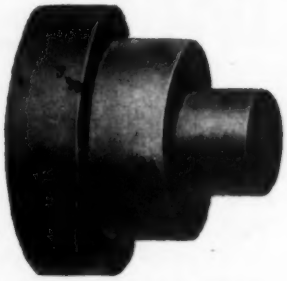

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We invite responsible firms to send direct to us for **FREE TRIAL SAMPLE** and descriptive pamphlet.

PERMANENT repairs to Castings, Heaters, Furnaces, Waterpipe Connections, etc., can be effected by the use of this **COMPOUND. AGE DOES NOT IMPAIR IT.** When hard it can be filed.

Manufactured by

The IRON & STEEL COMPOUNDS MFG. CO.,
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A NEW STEEL BARROW

(PATENTED)

"BRABY'S BALANCED BARROW."

The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is **25 per cent.** greater than the ordinary style, yet it can be wheeled with **half the labour**, and can be emptied **much more quickly**. It is a **perfectly balanced** barrow, and a full load can be **easily wheeled by a boy.**

NOTE.—This Barrow can be taken right up to mouth of furnace and the ashes drawn into the barrow direct from the furnace.

The "B.B.B."

BRABY for high grade **STEEL**
SHEETS & PLATES up to 15 FEET LONG.
RANGE of GAUGES 8 to 30 W.G.
RANGE of WIDTHS 12 to 60 in.

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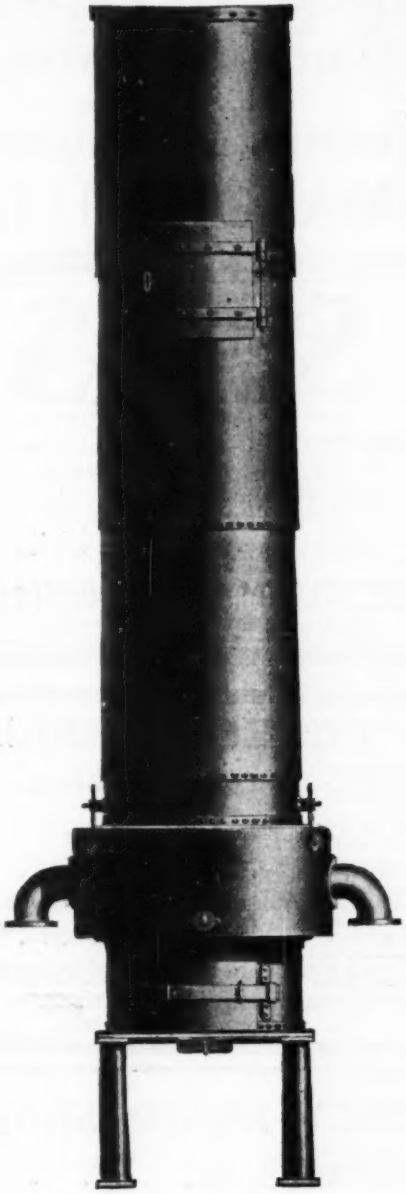

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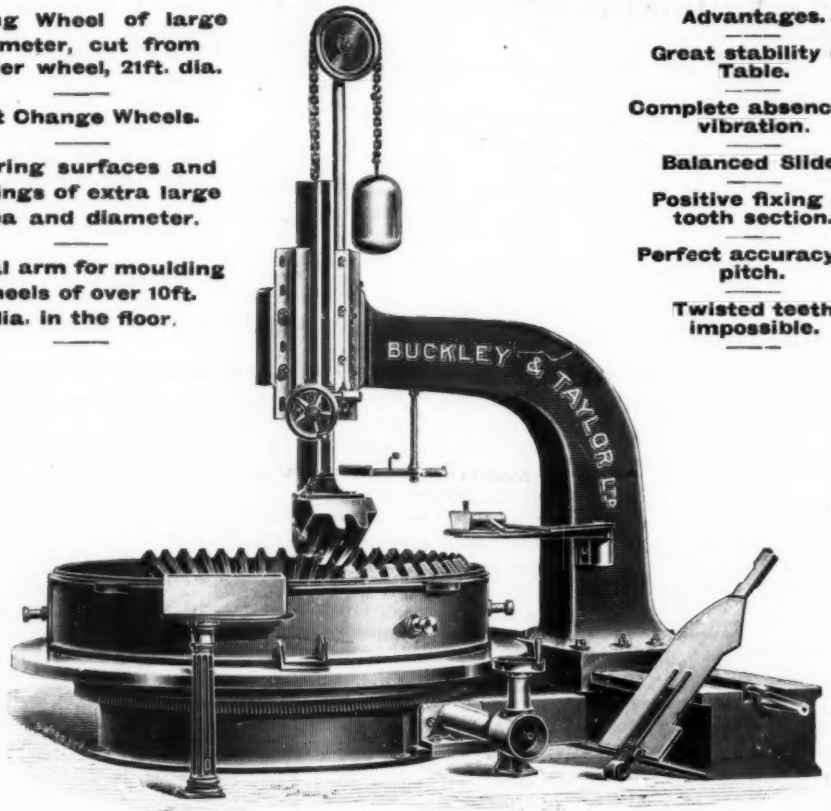

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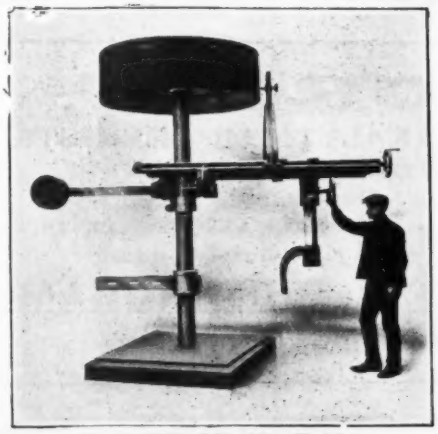

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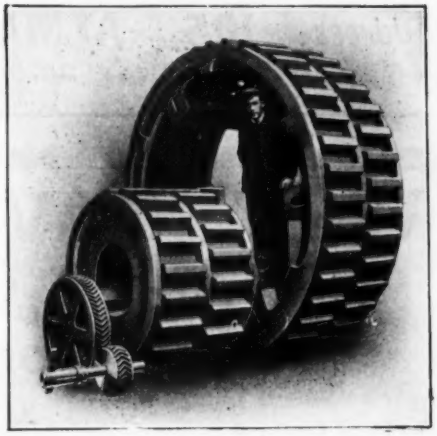

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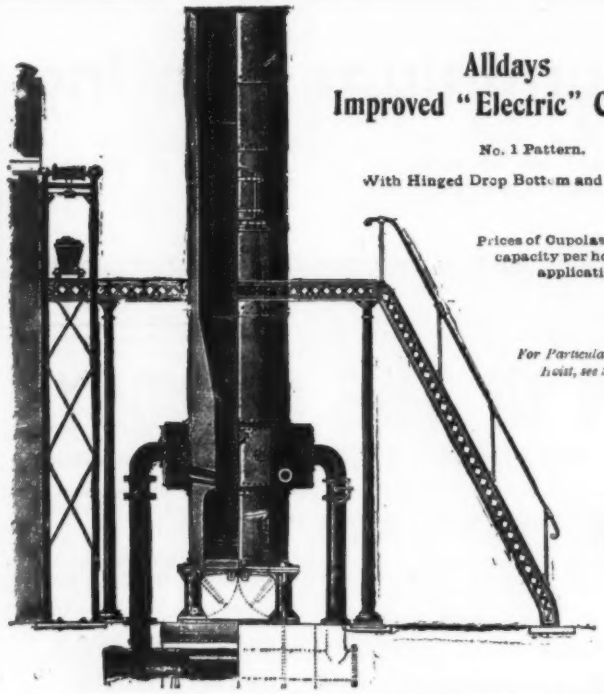

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News Notice to British Foundrymen.

We have recently entered into an agreement with the publishers of this JOURNAL to make use of this page in telling British Foundrymen of a remarkable sytem of improved foundry practice that, when followed, guarantees to produce better and stronger castings, lower costs on material, reduces losses to the minimum and do away with the use of chillers, to cure liquid contraction and shrinkage, as it absolutely prevents draws or soft spots at the intersection of light and heavy sections.

The basis on which these things are accomplished is mixing of irons by analysis, scientific cupola practice, and the making of semi-steel by McLain's Method. These three principles of foundry practice are known as McLain's System, so called after their principal exponent and originator, David McLain, of Milwaukee, Wis., U.S.A.

This System, while somewhat new to British Foundrymen, has been in use in the United States and Canada for over 5 years. Hundreds of foundries in these two countries are already following this system, and as it deals largely with the correction of all metallurgical troubles, and the sources of such troubles are the same the world over although details of practice may vary, it should be of the greatest interest to every British Foundryman to know just what this system can do for him in his foundry.

The McLain Method of making Semi-Steel is the only successful one ever discovered for making commerically usable semi-steel castings. It enables the founder to use 10 to 50 per cent. steel scrap in cupola mixtures, depending on the section of the castings. The castings resulting are close grained and tough, yet machine easily. They are free from blow holes or hard spots, are better, stronger, test higher, machine easier, cost less and command a higher price than good grey iron.

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We suggest that British Foundrymen wishing to get additional information and helpful suggestions on the above practice, address Mc'Lain's System, Milwaukee, Wis., U.S.A., or fill out the coupon below.

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The undersigned will be glad to receive additional information regarding your system of improved practice, free of cost.

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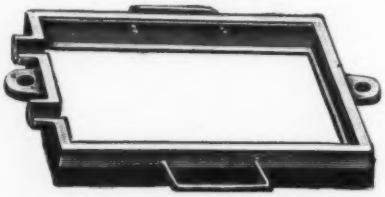

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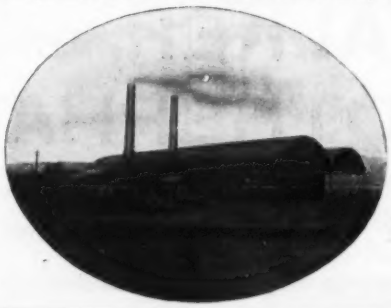

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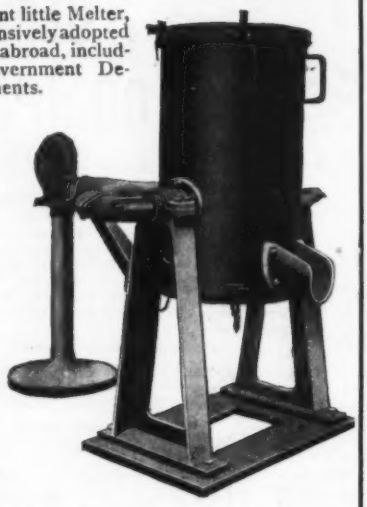

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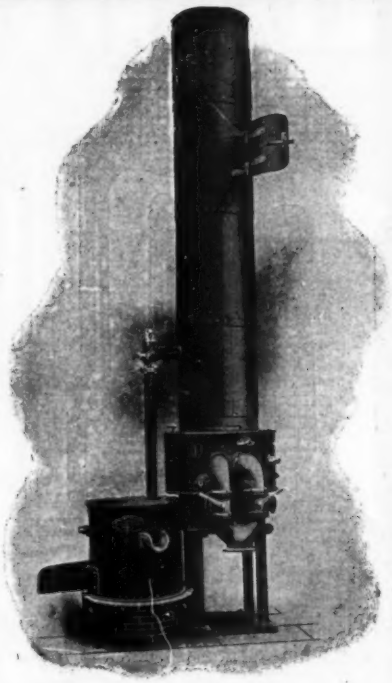

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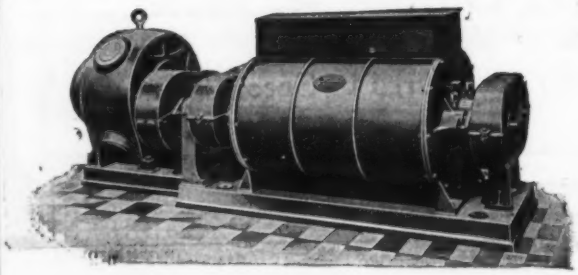

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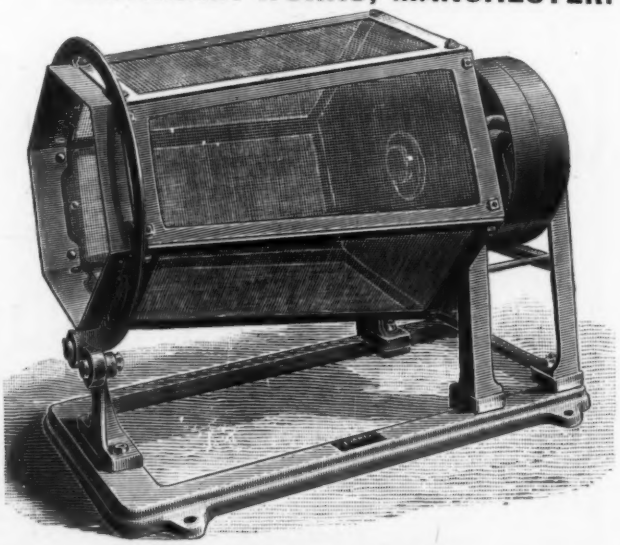

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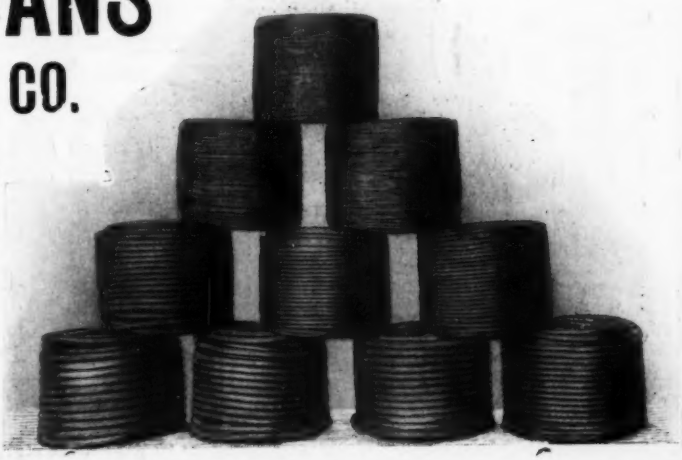

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